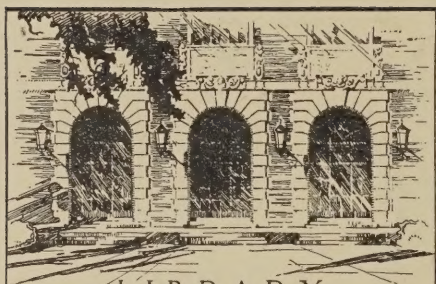

DEPARTMENT OF THE INTERIOR

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UNITED STATES GEOLOGICAL SURVEY

VOLUME X

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UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

DINOCERATA

A

MONOGRAPH

OF AN

EXTINCT ORDER OF GIGANTIC MAMMALS

BY

OTHNIEL CHARLES MARSH

WASHINGTON
GOVERNMENT PRINTING OFFICE
1886

UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF PALÆONTOLOGY,
NEW HAVEN, CONN., *December* 18, 1884.

SIR:

In compliance with your letter of instructions, dated October 5, 1882, I have the honor to transmit herewith a Monograph of the DINOCERATA, an extinct order of Mammals discovered in the Eocene deposits of Wyoming Territory.

Very respectfully,

Your obedient servant,

O. C. MARSH,
Palæontologist-in-Charge.

HON. J. W. POWELL,
Director of the U. S. Geological Survey,
Washington, D. C.

TABLE OF CONTENTS.

ILLUSTRATIONS.

LIST OF PLATES.

LIST OF WOODCUTS.

INTRODUCTION.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIV.

The same general plan will be followed in the third Monograph, on the *Sauropoda*, which comes next in the series, and is now approaching completion. Ninety lithographic plates, and a large number of woodcuts, will be used to illustrate it. The fourth volume, on the *Stegosauria*, which follows, will likewise be very fully illustrated. A great portion of the lithographic plates to accompany it are finished, and part of them are already printed. Other monographs of the series, now in preparation, will appear in due time.

To General Sheridan and General Sherman of the United States Army, the author's best thanks are due for important assistance in his Western explorations, during which the discoveries here recorded were made. Other officers of the Army, who commanded his escort, and aided him in many ways, also deserve grateful acknowledgments.

For direct aid in collecting the specimens on which the present volume is based, the author is indebted to the members of the Yale College expeditions, which explored so successfully many portions of the Western Territories.

The thanks of the author are especially due to Mr. Oscar Harger, assistant in the Yale Museum, for valuable aid in the field, and in the preparation of the present memoir. Messrs. S. W. Williston, G. Baur, and M. Schlosser, also his assistants, have likewise aided, especially while the volume was passing through the press.

Yale College, New Haven, Conn., December 15th, 1884.

INTRODUCTION.

Among the many extinct animals discovered in the Tertiary deposits of the Rocky Mountain region, none, perhaps, are more remarkable than the huge mammals of the order *Dinocerata*. Their remains have hitherto been found in a single Eocene lake-basin in Wyoming, and none are known from any other part of this country, or from the Old World. These gigantic beasts, which nearly equalled the elephant in size, roamed in great numbers about the borders of the ancient tropical lake in which many of them were entombed.

This lake-basin, now drained by the Green River, the main tributary of the Colorado, slowly filled up with sediment, but remained a lake so long that the deposits formed in it, during Eocene time, reached a vertical thickness of more than a mile. The Wasatch Mountains on the West, and the Uinta chain on the South, were the main sources of this sediment, and still protect it, but the Wind River range to the North, and other mountain elevations, also sent down a vast amount of material into this great fresh-water lake, then more than one hundred miles in extent.

At the present time, this ancient lake-basin, now six to eight thousand feet above the sea, shows evidence of a vast erosion, and probably more than one-half of the deposits once left in it have been washed away, mainly through the Colorado River. What remains forms one of the most picturesque regions in the whole West, veritable *Mauvaises terres*, or bad lands, where slow denudation has carved out cliffs, peaks, and columns of the most fantastic shapes, and varied colors.

This same action has brought to light the remains of many extinct animals, and the bones of the *Dinocerata*, from their great size, naturally first attract the attention of the explorer.

The first remains of the *Dinocerata* discovered were found by the author, in September, 1870, while investigating this Eocene lake-basin, which had never before been explored. Various remains of this group were also collected by other members of the expedition, and among the specimens thus secured was the type of *Tinoceras anceps*, described by the author in the following year, and now more fully in the present volume. In the same geological horizon with these remains, a rich and varied vertebrate fauna, hitherto unknown, was found.

Among the animals here represented were ancestral forms of the modern horse and tapir, and also of the pig. Many others were found related to the recent Lemurs; also various Carnivors, Insectivors, Rodents, and small Marsupials; and of still more importance, remains were here brought to light of another new order of mammals, the Tillodonts, quite unlike any now living. Crocodiles, tortoises, lizards, serpents, and fishes also swarmed in and about the waters of this ancient lake, while around its borders grew palms, and other tropical vegetation.

A later Eocene lake-basin, south of the Uinta Mountains, was discovered, in October, 1870, by the same expedition, and named by the author Uinta basin. In the attempt to explore it, our party endured much hardship, and also were exposed to serious danger, since we had only a small escort of United States soldiers, and the region visited was one of the favorite resorts of the Uinta Utes. These Indians were then, many of them, insolent and aggressive, and since have been openly hostile, at one time massacring a large body of government troops sent against them. Two subsequent attempts by the author to explore this basin met with little success. This lower lake was of upper Eocene age, and its extinct fauna appears to correspond more nearly to that of the Paris basin than any other yet discovered in this country.[1]

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[1] Some results of this Expedition may be found in an article by the author on the "Geology of the Eastern Uintah Mountains," American Journal of Science and Arts, vol. i, p. 191, March, 1871.

The remarkable Eocene basin North of the Uinta Mountains, where alone the *Dinocerata* had been found, offered so inviting a field for exploration, that in the spring of the following year, 1871, the author began its systematic investigation. An expedition was again organized, with an escort of United States soldiers, and the work continued during the entire season. Among the very large collections thus secured, were numerous specimens of the *Dinocerata*, which furnished important characters of the group.

FIG. 1.

MAP SHOWING REGION OF DINOCERAS BEDS.

In the succeeding spring, 1872, the explorations in this region were continued, and soon resulted in the discovery of the type specimen, including the skull and a large portion of the skeleton, of *Dinoceras mirabile*, and on this new genus the author based the order *Dinocerata*

Other important specimens, obtained at this time, and described by the author, were the types of *Dinoceras lucare*, *Tinoceras grande*, *Tinoceras lacustre*, and others of scarcely less interest.

In the following season, 1873, the author organized another large expedition, with government escort, and made a very careful examination of the regions in this same basin that remained unexplored. One of the specimens of special importance thus secured was the type of *Dinoceras laticeps*, with the skull and lower jaw nearly complete. Many other individuals of the *Dinocerata* were also discovered, and the abundant material then collected was sufficient to clear up most of the doubtful points in this group.

The research was continued systematically during the next season, also, 1874, and again in 1875, with good results. Since then, various small parties, at different times, have been equipped and sent out by the author to collect in this basin; and, finally, during the entire season of 1882, the work was vigorously prosecuted under the direction of the author, and, from July of that year, under the auspices of the United States Geological Survey.

The specimens thus brought together by all these various expeditions and parties are now in the museum at Yale College, and represent more than two hundred individuals of the *Dinocerata* alone. Of these, not less than seventy-five have portions of the skull more or less perfectly preserved, and in more than twenty it is in good condition. The present volume is based on this material, amply sufficient, it is believed, to illustrate all the more important parts of the structure of this remarkable group.

The remaining material of the *Dinocerata*, now known, consists of a few specimens collected by Dr. Leidy in 1872, including the type of the genus *Uintatherium;* various remains secured in the same year by Prof. Cope, to which he applied the names *Loxolophodon* and *Eobasileus,* with a later acquisition, called *Bathyopsis;* and a number of specimens more

recently obtained by parties from Princeton College. Although these remains show few, if any, characters of the *Dinocerata* not better represented in the larger collection of the Yale Museum, full references to the more important specimens, in most cases with illustrations, are given in the present memoir, especially in the Synopsis at the end of the volume.

The *Dinocerata* have hitherto been found in a well marked geological horizon of the middle Eocene. The relations of this horizon to other deposits of Tertiary age are important, and cannot readily be understood without having in mind the principal changes that took place in the geology of the Rocky Mountain region during this period. These changes and their results may be briefly stated as follows:

The Tertiary of Western America comprises the most extensive series of deposits of this age known to geologists, and important breaks in both the rocks and the fossils separate it into three well-marked divisions. These natural divisions are not the exact equivalents of the Eocene, Miocene, and Pliocene of Europe, although usually so considered, and known by the same names; but, in general, the fauna of each appears to be older than that of its corresponding representative in the other hemisphere; an important fact, but little recognized. This partial resemblance of our extinct faunas to others in regions widely separated, where the formations are doubtless somewhat different in geological age, is precisely what we might expect, if, as was probable, the main migrations took place from this continent. It is better at once to recognize this general principle, rather than attempt to bring into exact parallelism formations that were not contemporaneous.

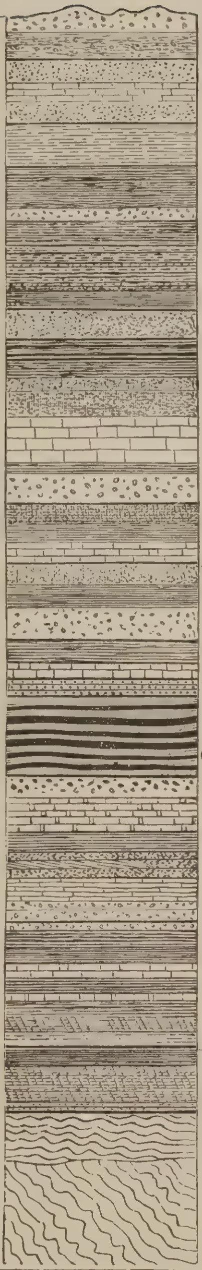
The fresh-water Eocene deposits of our Western Territories, which are in the same region at least two miles in vertical thickness, may be separated into three distinct subdivisions. The lowest of these, resting unconformably on the Cretaceous, has been termed the Vermilion Creek, or Wasatch, group. It contains a well-marked mammalian fauna, the

largest and most characteristic genus of which is the ungulate *Coryphodon*, and hence the author has called these deposits the Coryphodon beds. The middle Eocene strata, which have been termed the Green River and Bridger series, has been designated by the author the Dinoceras beds, as the gigantic animals of this order are only found here. It is, however, better to separate the Green River series, under the term Heliobatis beds, and this is done in the present volume. The name Dinoceras beds will then apply to the Bridger series alone. The uppermost Eocene, or the Uinta group, is especially well characterized by large mammals of the genus *Diplacodon*, and hence termed by the author Diplacodon beds. The fauna of each of these three subdivisions was essentially distinct, and the fossil remains of each were entombed in different and successive ancient lakes.

It is important to remember that these Eocene lake-basins all lie between the Rocky Mountains on the east and the Wasatch Range on the west, or along the high central plateau of the continent. As these mountain chains were elevated, the inclosed Cretaceous sea, cut off from the ocean, gradually freshened, and formed these extensive lakes, while the surrounding land was covered with a luxuriant tropical vegetation, and with many strange forms of animal life. As the upward movement of this region continued, these lake-basins, which for ages had been filling up, preserving in their sediments a faithful record of Eocene life-history, were slowly drained by the constant deepening of the outflowing rivers, and they have since remained essentially dry land.

The Miocene lake-basins are on the flanks of this region, where only land had been since the close of the Cretaceous. These basins contain three faunas, nearly or quite distinct. The lowest Miocene, which is found east of the Rocky Mountains, alone contains the peculiar mammals known as the *Brontotheridæ*, and these deposits have been called by the author the Brontotherium beds. The strata next above, which represent the middle Miocene, have as their most characteristic fossil the genus *Oreodon*, and are known as the Oreodon beds. The upper Miocene, which occurs in Oregon, is of great thickness, and from one of its most important fossils, *Miohippus*, has been designated as the Miohippus series. The climate here during this period was warm temperate.

FIG. 2.



CENOZOIC.	Recent.			Tapir, Peccary, Bison, Llama.
	Quaternary.			*Bos, Equus, Megatherium, Mylodon.*
	Tertiary.	Pliocene.	Equus Beds.	*Equus, Tapirus Elephas.*
			Pliohippus Beds.	*Pliohippus, Tapiravus, Mastodon, Protohippus, Procamelus, Aceratherium, Bos, Morotherium.*
		Miocene.	Miohippus Beds.	*Miohippus, Diceratherium, Thinohyus.*
			Oreodon Beds.	*Oreodon, Eporeodon, Hyænodon, Hyracodon.* Edentates (*Moropus*).
			Brontotherium Beds	*Brontotherium, Menodus, Mesohippus, Elotherium.*
		Eocene.	Diplacodon Beds.	*Diplacodon, Epihippus, Amynodon.*
			Dinoceras Beds.	*Dinoceras, Tinoceras, Uintatherium, Limnohyus, Palæosyops, Orohippus, Helaletes, Hyrachyus, Colonoceras.*
			Green River, or Heliobatis, Beds.	*Heliobatis, Amia, Lepidosteus.*
			Coryphodon Beds.	*Coryphodon, Eohippus.* Lemurs, Carnivores, Ungulates, Tillodonts, Rodents, Serpents.
MESOZOIC.	Cretaceous.		Laramie Series, or Hadrosaurus Beds.	*Hadrosaurus, Dryptosaurus* (*Lælaps*).
			Fox Hill group.	
			Colorado Series. or Pteranodon Beds.	Birds with Teeth (*Odontornithes*), *Hesperornis, Ichthyornis.* Mosasaurs, *Edestosaurus, Lestosaurus, Tylosaurus.* Pterodactyls (*Pteranodon*). Plesiosaurs.
			Dakota Group.	
	Jurassic.		Atlantosaurus Beds	Dinosaurs, *Atlantosaurus, Brontosaurus, Morosaurus, Diplodocus, Stegosaurus, Camptonotus, Allosaurus.* Turtles. Crocodiles. Mammals (*Dryolestes, Stylacodon, Tinodon, Ctenacodon*). Bird (*Laopteryx*). *Baptanodon* (*Sauranodon*).
			Baptanodon Beds.	
	Triassic.		Otozoum, or Conn. River, Beds.	First Mammals (*Dromatherium*). Dinosaur Foot-prints, *Amphisaurus,* Crocodiles (*Belodon*).
PALEOZOIC.	Permian.		Nothodon Beds.	Reptiles (*Nothodon, Sphenacodon*).
	Carboniferous		Coal Measures, or Eosaurus Beds.	First Reptiles (?) *Eosaurus.*
			Subcarboniferous. or Sauropus Beds.	First known Amphibians (Labyrinthodonts), *Sauropus.*
	Devonian.		Dinichthys Beds.	*Dinichthys.*
			Schoharie Grit.	First known Fishes.
	Silurian.		Upper Silurian.	No Vertebrates known.
			Lower Silurian.	
	Cambrian.		Primordial.	
	Archæan.		Huronian.	
			Laurentian.	

SECTION TO ILLUSTRATE VERTEBRATE LIFE IN AMERICA.

Above the Miocene, east of the Rocky Mountains, and on the Pacific coast, the Pliocene is well developed, and is rich in vertebrate remains. The strata rest unconformably on the Miocene, and there is a well-marked faunal change at this point, modern types now first making their appearance. For these reasons, we are justified in separating the Miocene from the Pliocene at this break; although in Europe, where no great break exists, the line seems to have been drawn at a somewhat higher horizon. Our Pliocene forms essentially a continuous series, although the upper beds may be distinguished from the lower by the presence of a true *Equus*, and some other existing genera. The Pliocene climate was similar to that of the Miocene. The Post-Pliocene beds contain many extinct mammals, and may thus be separated from recent deposits.[1]

With this introduction, the table of strata on page 7 will make clear the general position of the geological horizon in which the *Dinocerata* are found, and especially its relation to other deposits of Tertiary age. To make the subject clearer to the general reader, the section is enlarged to include the whole geological series. The names applied to the different horizons, some used here for the first time, are, in general, those of the most important vertebrates found in each, and the section thus becomes a condensed index of vertebrate life in America.

The localities in which the *Dinocerata* have been found are on both sides of the Green River, and mainly south of the Union Pacific Railroad, in Wyoming. Of two hundred individuals in the Yale Museum, about equal numbers were found east and west of this River, the distance between the extreme localities in this direction being more than one hundred miles. The map on page 3 covers this region, and the more important localities referred to in the volume are there indicated.

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[1] For a more complete presentation of this subject, see the author's address on the *Introduction and Succession of Vertebrate Life in America*, delivered before the American Association for the Advancement of Science, at Nashville, Tenn., Aug., 1877.

The remains of the *Dinocerata* are imbedded usually in indurated clays, gray or green in color, but sometimes they are found in hard sandstone. The series of strata enclosing them are at least five hundred feet in thickness in the same region, and all taken together are probably one thousand feet.

Among the fossils found associated with the *Dinocerata* are *Limnohyus* and *Palæosyops*, two genera of perissodactyl ungulates. They were somewhat larger than a Tapir, and in these strata are next in size to the *Dinocerata*. One or the other of these genera occurs wherever the *Dinocerata* have yet been found, but the remains extend through a greater thickness of strata than those of the former group. Another genus of ungulates in this horizon is *Orohippus*, a four-toed ancestor of the horse. Other prominent genera are *Colonoceras*, *Helaletes*, and *Hyrachyus*, related distantly to the Tapir and Rhinoceros.

Two genera, *Tillotherium* and *Stylinodon*, also found here, represent a remarkable order, named by the author, *Tillodontia*. They were nearly as large as a Tapir, and possessed characters resembling the Ungulates, the Carnivors, and the Rodents.

Among the Carnivors, the most formidable was *Limnofelis*, nearly as large as a lion, *Oreocyon*, of almost equal size, *Dromocyon*, somewhat smaller, and *Limnocyon*, about as large as a fox. Among the Lemuroid forms were *Hyopsodus* and *Lemuravus*, forming the family *Lemuravidæ*, and having some affinities with the South American Marmosets.

In addition to these, there were Marsupials, Insectivors, Chiroptera, and many Rodents, but apparently no true Quadrumana, or Edentates.

Besides these Mammals, there were numerous Reptiles, especially crocodiles, turtles, lizards, and serpents, in great numbers. Fishes were also abundant, especially the genera *Amia* and *Lepidosteus*.

The *Dinocerata* form a well marked order in the great group of *Ungulata*. In some of their characters, they resemble the Artiodactyls (*Paraxonia*); in others, they are like the Perissodactyls (*Mesaxonia*); and

in others still, they agree with the Proboscidians. The points of similarity, however, are in most cases general characters, which point back to an earlier, primitive, ungulate, rather than indicate a near affinity with existing forms of these groups. This subject will be more fully discussed in the concluding chapters of the present memoir.

The *Dinocerata*, so far as now definitely known, may be placed in three genera, *Dinoceras*, Marsh, *Tinoceras*, Marsh, and *Uintatherium*, Leidy. The type specimen of *Uintatherium* was discovered near the base of the series of strata containing the remains of the *Dinocerata*. *Dinoceras*, so far as known, occurs only at a higher horizon, while *Tinoceras* has been found at the highest level of all. The characters of these three genera correspond in general with their geological position. *Uintatherium* appears to be the most primitive type, and *Tinoceras* the most specialized, *Dinoceras* being an intermediate form. The material at hand for determining the characters of the two latter forms is abundant, but in regard to *Uintatherium*, some important points relating both to the skull and skeleton still remain in doubt.

The number of species of the known *Dinocerata* is a difficult matter to determine, especially as the limitations between species are now generally regarded as uncertain. About thirty forms, more or less distinct, are recognized in the Synopsis at the end of the volume. The number might easily be increased, if fragmentary specimens were used as the basis for specific names.

DINOCERATA.

CHAPTER I.

THE SKULL.

(Plates I–XIX, LV, and LVI.)

The skull of *Dinoceras mirabile*, the type of the genus *Dinoceras*, on which the order *Dinocerata* was based, is, fortunately, the most perfect in preservation of any yet discovered in this group. It has in addition the great advantage for study of having belonged to an animal fully adult, but not so old as to have the more important sutures of the skull obliterated. It was, moreover, imbedded in so soft a matrix that the brain-cavity and the foramina leading from it could be worked out without difficulty.

In removing the skull from the rock, on the high and almost inaccessible cliff where it was found, two or three important fragments were lost, but the author subsequently made a systematic and laborious search, and recovered them from the bottom of a deep ravine where they had been washed down and covered up.

In its present nearly perfect condition, this skull is well adapted to show the typical characters of this part, both in the genus it represents, and in the order *Dinocerata*, and it will be largely used for this purpose in the following pages. The fact that a considerable portion of the skeleton, also, was found with this skull makes the individual especially worthy to be a type.

The number of this specimen, in the Catalogue of the Yale Museum, is 1036, and in the following pages this number will be used to distinguish this type from other individuals of the same species. Other important specimens will likewise be designated by their catalogue numbers.

The skull of *Dinoceras mirabile* is long and narrow, the facial portion being greatly produced. The basal line, extending from the end of the premaxillaries along the palate to the lower margin of the foramen magnum, is nearly straight. The top of the skull supports three, separate, transverse pairs of osseous elevations, or horn-cores, which form its most conspicuous feature, and suggested the name of the genus. The smallest of these protuberances are situated near the extremity of the nasals; two others, much larger, arise from the maxillaries, in front of the orbits; while the largest are mainly on the parietals, and are supported by an enormous crest, which extends from near the orbits entirely around the lateral and posterior margins of the true cranium. These general characters are well shown in Plate I, which represents the skull of the type specimen.

There are no upper incisors, but the canines in the male are enormously developed, forming sharp, trenchant, decurved tusks, which were each protected by a dependent process on the lower jaws. The premolar and molar teeth are very small.

The orbit is large, and confluent with the temporal fossa. The latter is of great extent posteriorly, but the zygomatic arches are only moderately expanded. There is no post-orbital process, but in *Dinoceras mirabile*, and in some other species, there is a prominence on the frontal bone, directly over the orbit.

The Nasal Bones.

The nasal bones are greatly elongated, being nearly half the length of the entire skull. They project forward over the anterior nares, and overhang the premaxillaries. They are thick and massive bones, especially in front, and are united together by a nearly straight suture.

In specimens not fully adult, this suture remains an open fissure, and even in some adults it is not closed, especially in the anterior part.

The osseous prominences on the extremity of the nasal bones are their most marked feature. These vary much in form and size in the different genera of the group, and appear to be characteristic of the species.

FIG. 3.

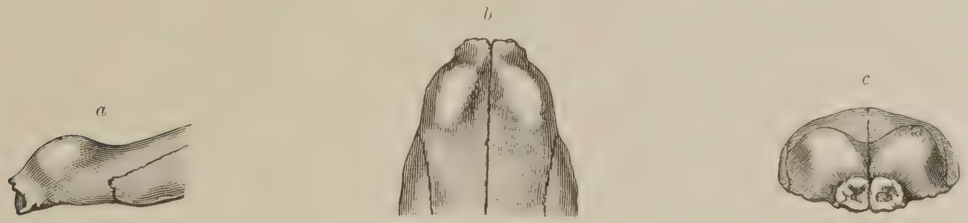


FIG. 4.

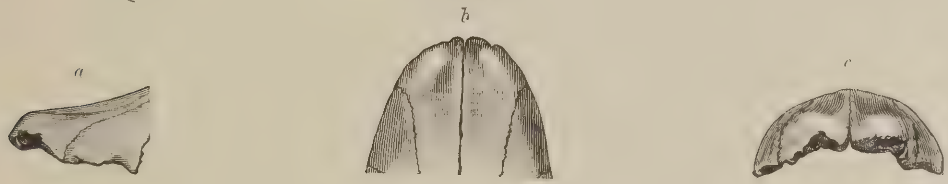


FIG. 5.

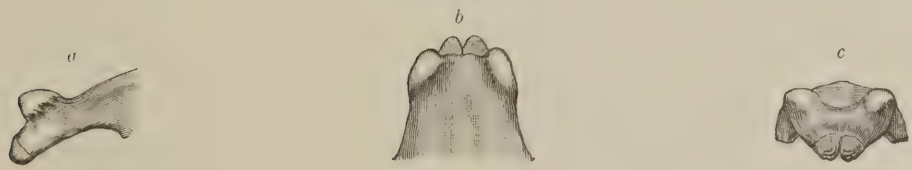


FIG. 6.

FIGURE 3.—Nasals of *Dinoceras mirabile*, Marsh (No. 1036); type specimen.
FIGURE 4.—Nasals of *Dinoceras distans*, Marsh (No. 1601); young male.
FIGURE 5.—Nasals of *Tinoceras pugnax*, Marsh (No. 1044).
FIGURE 6.—Nasals of *Tinoceras annectens*, Marsh (No. 1043).
a. side view; *b*. top view; *c*. front view.

All the figures are one-fifth natural size.

In *Dinoceras*, they are small and sessile, and are directed upward, and somewhat outward; in *Tinoceras* they are larger, in most specimens, and project more horizontally, usually not beyond the apex of the nasals. Some of the characteristic forms of these nasals are given above, figures 3–6, page 13, and others will be found under the different species in the Synopsis at the end of the volume.

On their lateral margins, the nasal bones unite by suture with the superior branch of the premaxillary, and, behind this, with the maxillaries up to the point where they join the frontals. These lateral sutures disappear in old animals, but are shown in the skull of *Dinoceras mirabile*, figured in Plate IV. Between the osseous protuberances, or horn-cores, of the maxillaries, the nasals thicken into a transverse ridge, which greatly strengthens the skull in this region. The development of this ridge varies in different species. The suture between the nasals and maxillaries thus appears to rise on the inner face of each maxillary prominence, but the nasals do not form any essential part of these elevations. From this transverse ridge, the nasals expand posteriorly, and meet the frontals by oblique sutures, converging behind to the median line. At the union with the frontals, the nasal bones are comparatively thin.

On their under surface, the nasal bones are each excavated by a broad deep groove, which is separated from its fellow by a sharp median ridge. These grooves extend from the anterior nasal opening back to the frontal bones, and then expand into large cavities immediately in front of the olfactory lobes of the brain. These olfactory chambers differ in form and size in different species. This part of the skull is shown in the sections represented in figures 30–33, pages 29 and 30.

Pre-Nasal Bones.

The anterior extremity of the nasal bones, in both *Dinoceras* and *Tinoceras*, is formed of an osseous projection, pointing forward and downward, and situated in front of and below the nasal protuberances. Several specimens in the Yale Museum show that this projection is formed

of two separate ossifications, each in front of its respective nasal bone. In figure 5, page 13, they are shown in position, with the sutures uniting them to the nasals, and to each other. These bones are a peculiar feature in the skull of *Dinocerata*, and may be called the pre-nasal bones. In very young animals, they are unossified; in adult animals, they are distinct, as in the specimen figured; but in very old animals they become co-ossified with the nasals, and with each other.

FIG. 7.

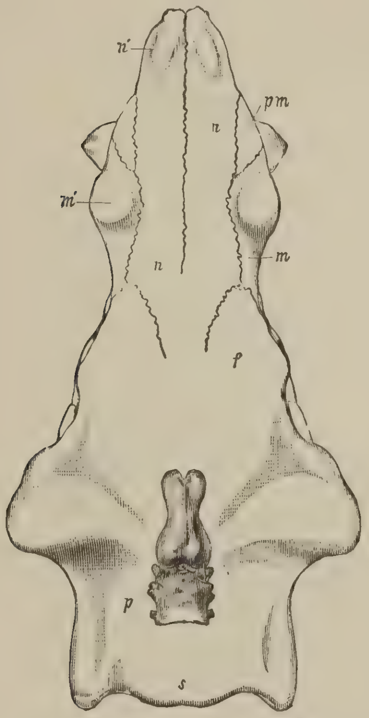


FIG. 8.

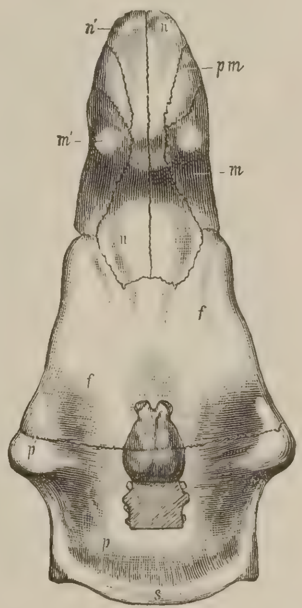


FIGURE 7.—Skull of *Dinoceras mirabile*, Marsh (No. 1036); with brain-cast in natural position; seen from above.
FIGURE 8.—The same view of a young specimen of *Dinoceras distans*, Marsh (No. 1601).

f. frontal bone; *m.* maxillary bone; *m'.* maxillary protuberance; *n.* nasal bone; *n'.* nasal protuberance; *p.* parietal bone; *p'.* parietal protuberance; *pm.* premaxillary bone; *s.* supra-occipital crest.

Both figures are one-eighth natural size.

When separate, they are subquadrate in form, flattened on the median line where they meet each other; and rugose posteriorly, for sutural union with the nasals. These pre-nasal bones appear to be homologous with the ossicle sometimes found at the extremity of the snout in suillines, especially in the genus *Sus*.

Frontal Bones.

The frontal bones in *Dinoceras mirabile* are shorter than the nasals. In all of the known skulls of the *Dinocerata*, the median suture uniting the two frontals is entirely obliterated. The sutures joining them with the nasals in front, and with the maxillaries on the side, is distinct in the type

Fig. 9.

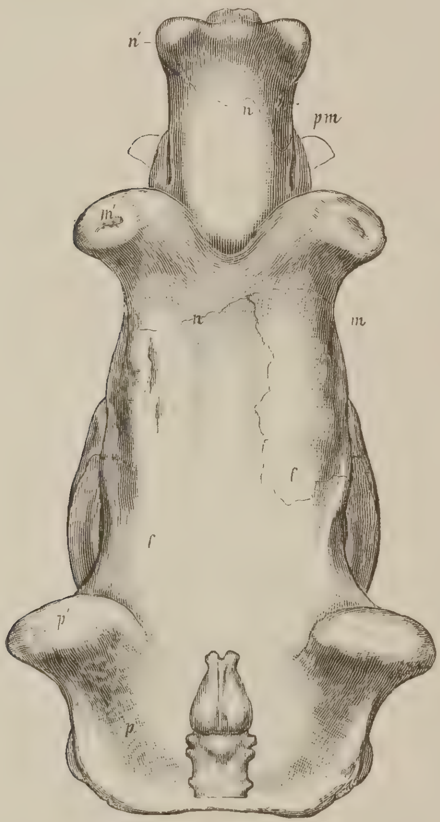


Fig. 10.

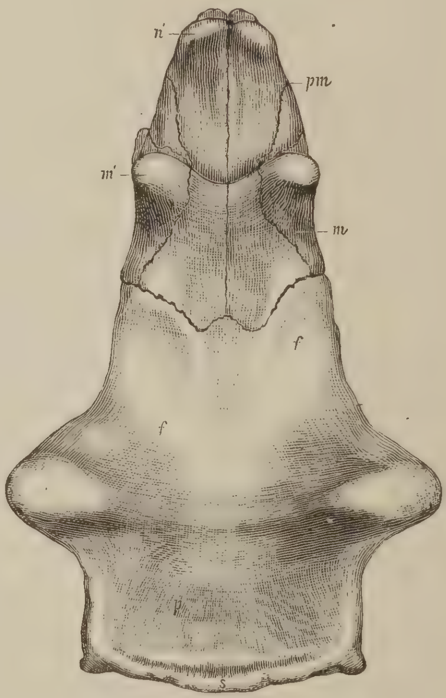


Figure 9.—Skull of *Tinoceras ingens*, Marsh (No. 1041); with brain-cast in position; seen from above.
Figure 10.—Same view of skull of *Dinoceras distans*, Marsh (No. 1235).

f. frontal bone; *m.* maxillary bone; *m'.* maxillary protuberance; *n.* nasal bone; *n'.* nasal protuberance; *p.* parietal bone; *p'.* parietal protuberance; *pm.* premaxillary bone; *s.* supraoccipital crest.

Both figures are one-eighth natural size.

of *Dinoceras mirabile*, as shown in Plates II and IV. In this specimen, there appeared to be indications of a suture uniting the frontals with the parietals, which indicated that the former bones were very short, and the latter very long. The fortunate discovery, however, of a very young individual of this genus has cleared up this point beyond doubt.

In this young specimen, the fronto-parietal suture is still open, and passes in a nearly straight line across the top of the cranium just in front of the summit of the cerebral hemispheres. It also divides the posterior elevations, or horn-cores, so as to leave the anterior part of them on the frontals, and the posterior and highest portion on the parietals. In all the other known specimens, this suture is nearly or quite obliterated, but distinct traces of it are seen in several crania in the Yale Museum.

FIG. 11

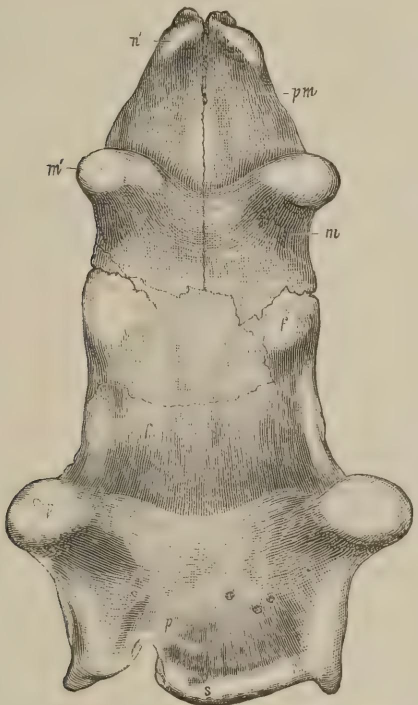


FIG. 12.

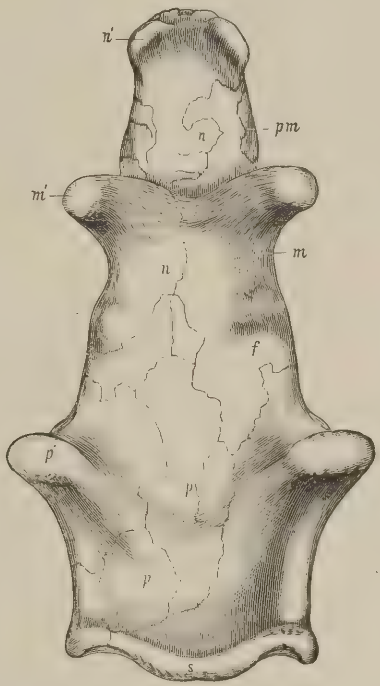


FIGURE 11.—Skull of *Uintatherium latifrons*, Marsh (No. 1231); seen from above.
FIGURE 12.—Same view of skull of *Tinoceras vagans*, Marsh (No. 1241).

f. frontal bone; *m.* maxillary bone; *m'.* maxillary protuberance; *n.* nasal bone; *n'.* nasal protuberance *p.* parietal bone; *p'.* parietal protuberance; *pm.* premaxillary bone; *s.* supraoccipital crest.

Both figures are one-eighth natural size.

The position of this suture, and also that uniting the frontals with the nasals, and the latter with their adjoining bones, is well shown in figure 8, page 15, which represents the young specimen (number 1601) above referred to.

In *Dinoceras mirabile* (number 1036), the frontals are comparatively thin in front where they join the nasals. Over the orbits, they become

thicker, and swell into a distinct prominence, which afforded protection to the eye below. From this point back to the posterior protuberances, or horn-cores, the lateral margin of the frontal is thickened into a strong crest, which rises nearly to the summit of the elevations, leaving a distinct notch where they terminate. This depression marks the position of the fronto-parietal suture, here entirely obliterated.

On the side of the cranium, the frontal bones are bounded anteriorly by the maxillary above, and, lower down, by the lachrymal, as shown in Plate II. Further back on the top of the skull, the frontals are depressed, forming a deep concavity, the lowest portion of which is usually in front of the brain-case. In the posterior portion of the frontals, there are numerous air cells, which materially lighten these bones in this part of the cranium.

The Parietal Bones.

In all of the crania of the *Dinocerata* examined, the parietal bones are firmly united to each other on the medial line, and with the supra-occipital behind. In the single young specimen already mentioned (number 1601), the anterior border of these bones is distinctly marked by sutures, as shown in figure 8, page 15. The large posterior protuberances, or horn-cores, are thus mainly on the parietal bones, and the lateral crest, behind these elevations, appears to be also composed of the parietals. These bones are thick and massive, especially over the brain-case, but like the frontals are lightened somewhat by air cavities, as shown in figure 35, page 31. Between the osseous elevations, or horn-cores, on the parietals, there is a distinct transverse ridge, which strengthens this part of the cranium, and partially divides into two portions the deep concavity enclosed by the lateral and posterior crests. On the sides of the cranium, the parietals form the upper portion of the large temporal fossæ. The suture between the parietal and squamosal below may often be distinctly made out, as shown in Plate II. The share of the parietals in the lofty occipital crest, cannot, at present, be determined with certainty, as here, even in the youngest specimens known, the sutures are obliterated.

The Occiput.

The occipital region in all the known *Dinocerata* is large, elevated, and subquadrate in outline. It varies much in shape and size in the different genera and species, and several of the principal forms are represented below in figures 13–18.

Fig. 13.

Fig. 14.

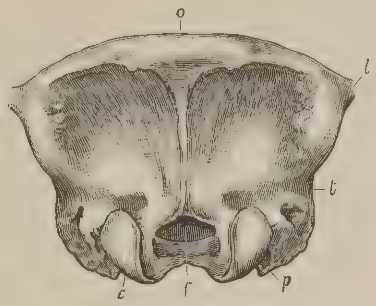


Fig. 15.

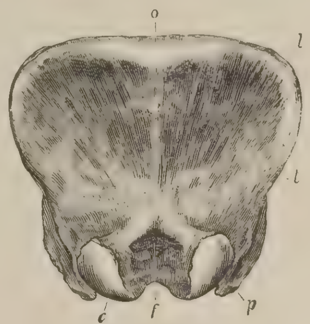


Fig. 16.

Fig. 17.

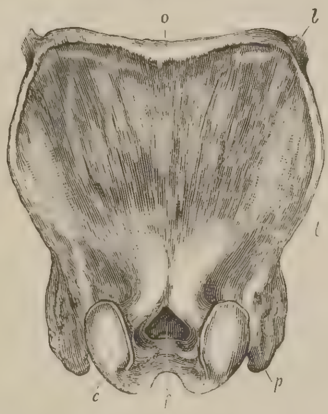


Fig. 18.

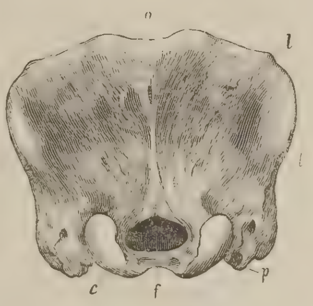


Figure 13.—Posterior surface of skull of *Dinoceras mirabile*, Marsh (No. 1036).
Figure 14.—Posterior surface of skull of *Dinoceras laticeps*, Marsh (No. 1039), male.
Figure 15.—Posterior surface of skull of *Dinoceras agreste*, Marsh (No. 1221).
Figure 16.—Posterior surface of skull of *Tinoceras affine*, Marsh (No. 1574)
Figure 17.—Posterior surface of skull of *Tinoceras ingens*, Marsh (No. 1041).
Figure 18.—Posterior surface of skull of *Tinoceras pugnax*, Marsh (No. 1044).

c. occipital condyle; *f.* foramen magnum; *l.* lateral crest; *o.* occipital crest; *p.* post-tympanic process; *t.* crest behind temporal fossa.

All the figures are one-eighth natural size.

In *Dinoceras mirabile* (number 1036), the occiput is remarkably rectangular in outline, as shown above in figure 13. Its general surface is concave, for the attachment of the powerful muscles and

ligaments which supported the head. The lofty occipital crest extends upward and backward, overhanging the occipital condyles, when the skull is in a horizontal position. The posterior margin of the large temporal fossa also extends well backward, forming the side of the occipital concavity, which is partially divided into two equal portions by a median vertical ridge. In some species, this ridge is very distinct, but, in others, it is almost entirely wanting.

The occipital condyles are large, and bounded externally in front and below by a deep groove. They project downward and backward, showing that the head was declined when in its natural position.

In *Dinoceras laticeps* (number 1039), the occiput is less elevated, and more expanded transversely, figure 14, page 19. Its concavity is divided into two portions by a distinct median vertical ridge. The foramen magnum, also, is expanded transversely, and is of moderate size. The occipital condyles are more elevated than in *Dinoceras mirabile*, a line joining their upper margins passing entirely above the foramen magnum.

In *Dinoceras agreste* (number 1221), a third type of occiput is seen, much more expanded above, as shown in figure 15, page 19. The foramen magnum is here subtriangular in outline, and the occipital condyles are placed similarly to those of *Dinoceras mirabile*.

In the genus *Tinoceras*, two distinct types of occiput are represented in the Yale Museum. In *Tinoceras ingens* (number 1041), the occiput is greatly elevated, somewhat concave above, and expanded at the sides. There is no median crest. The foramen magnum is triangular in outline, and comparatively small, with its upper border lower than the superior margins of the occipital condyles, as seen in figure 17, page 19.

In *Tinoceras pugnax* (number 1044), the occiput is less elevated, and more nearly quadrate in outline. The foramen magnum is large, and transversely expanded. The occipital condyles extend above its upper margin, as shown in figure 18, page 19. In other species of the *Dinocerata*, the occiput shows an equal variety of forms.

In *Dinoceras mirabile* (number 1036), there is a small, but distinct, par-occipital process of the ex-occipital, directed downward and outward.

In the type of *Uintatherium*, this process appears to be nearly obsolete. In front of this process is the suture uniting the ex-occipital directly with the squamosal, thus excluding the mastoid from the external surface of the skull, as in Rhinoceros. The tympanic portion of the periotic, also, does not reach the external surface.

FIG. 19.

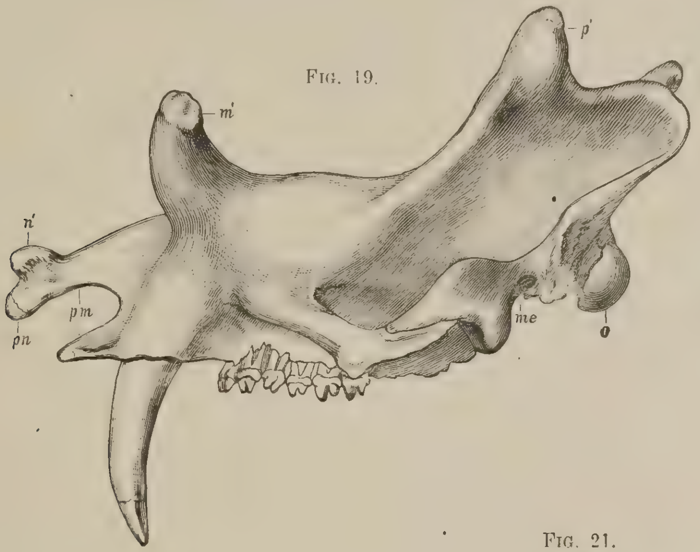


FIG. 20.

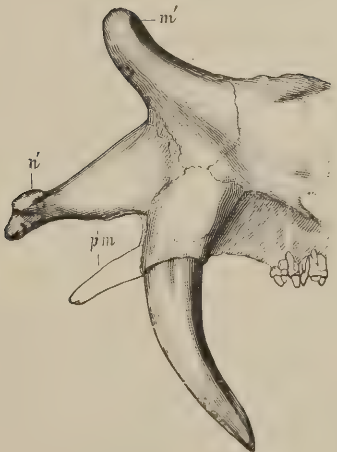


FIG. 21.

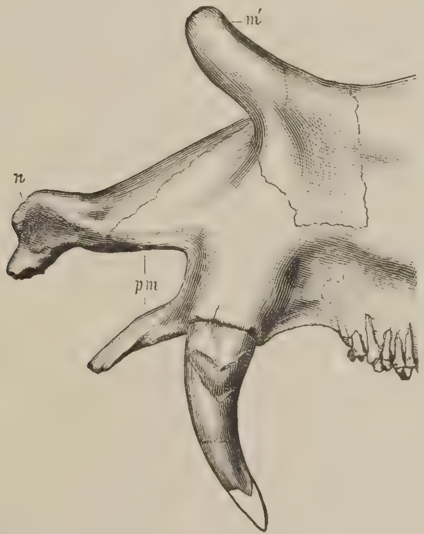


FIGURE 19.—Side view of skull of *Tinoceras pugnax*, Marsh (No. 1044).
FIGURE 20.—Anterior part of skull of *Tinoceras grande*, Marsh (No. 1040).
FIGURE 21.—Anterior part of skull of *Tinoceras annectens*, Marsh (No. 1043).

m′. maxillary protuberance; *me*. external auditory meatus; *n′*. nasal protuberance; *o*. occipital condyle; *p′*. parietal protuberance; *pm*. premaxillary bone; *pn*. prenasal ossicle.

All the figures are one-eighth natural size.

The Squamosal Bones.

The squamosal forms the lower portion of the temporal fossa, and sends down a massive post-glenoid process (Plate II, *s*), which bounds in front the external auditory meatus. The latter has for its posterior border the post-tympanic process of the squamosal, which unites directly with the par-occipital process by close suture.

The periotic and tympanic bones are co-ossified, but not with the squamosal. The periotic has a distinct floccular fossa on its inner side. The tympanic is small, and is not expanded into a distinct bulla.

The squamosal sends forward a strong zygomatic process, which resembles that in *Tapirus*. This process overlaps the malar, uniting to it by a straight, horizontal, suture, which, in very old animals, may nearly or quite disappear.

The Malar Bones.

The malar bone completes the anterior portion of the zygomatic arch, extending to the front of the orbit, as shown in Plate II, *ma*. The suture uniting the malar with the maxillary remains distinct till adult life, and may usually be traced, even in old animals. This forward extension of the malar bone is a general ungulate character, and quite different from what is seen in the Proboscidians, where the malar forms the middle portion only of the zygomatic arch. Union of malar with zygomatic process.

The Lachrymal Bones.

The lachrymal is large, and forms the anterior border of the orbit, as shown in Plate II, *l*. It is perforated by a large foramen. In *Dinoceras*, this opening is well within the orbit. In some species of *Tinoceras*, it is outside the orbit. The base of the lachrymal is excavated for the posterior opening of the large antorbital foramen.

The Maxillaries.

In all the *Dinocerata*, the maxillary bones form a large portion of the lateral surface of the skull. They contain all the teeth, except those of the lower jaw, and also expand into the large median pair of osseous elevations, or horn-cores. On the external lateral surface, the maxillaries unite above with the frontals by suture; below this, with the lachrymals, and further down with the malar. This is well shown in the figure of *Dinoceras mirabile*, Plate II, *m*. In front, the maxillaries unite with the pre-maxillaries by a nearly straight, and nearly vertical, suture. Above, they join the nasals, as already described.

The large canine tusk is entirely enclosed in the maxillary, and in the genus *Dinoceras* its root extends upward into the base of the maxillary horn-core. In all known *Dinocerata*, there is a diastema between the upper canine and the pre-molars. The latter are small, and form with the molars a continuous series. On their inner surface, the maxillaries send in strong palatine plates, which meet on the median line. The maxillary is perforated by a large antorbital foramen, the outlet of which is concealed, in the side view of the skull, by a ridge extending upward in front of the orbit. Its position is shown in figures 22–24, *c*, page 25.

The Premaxillaries.

The premaxillary bones are edentulous, and, even in young specimens, contain no teeth. These bones have three distinct branches, the largest of which extends well forward below the anterior nasal opening. The second branch also extends forward above this opening, forming with the nasal its superior border, as shown in the type of *Dinoceras mirabile*, Plate II, *pm*. The third branch is a horizontal plate extending inward to the median line, where it joins its fellow, and thus completes the anterior portion of the palate.

The anterior free portions of the premaxillaries are well separated on their palatal surface, but these bones meet somewhat in front of the anterior

palatal foramina. Near this point, the palatine plates are united by suture on the median line, and this suture is continued backward along the palate until it meets with the median suture between the maxillaries. The anterior palatine foramina are narrow fissures, rounded in front, and separating the lateral portions of the premaxillaries from the palatine plates, as in *Equus*. The latter plates unite posteriorly by suture with the adjoining maxillaries, as shown in Plate V, *pm*.

The premaxillaries vary much in form in the different genera and species of *Dinocerata*. Two of the principal forms in the genus *Dinoceras* are shown in figures 26 and 27, page 26, and two of the genus *Tinoceras*, in figures 28 and 29, on page 27.

The Palate.

In all the *Dinocerata*, the palate is very narrow, and much excavated, especially in front. The bony palate extends back as far as the last upper molar, and in some specimens beyond it. Each maxillary articulates with the corresponding premaxillary by a suture commencing on the palatal surface, in front of the large canine alveolus, and running just within the border of the alveolus to near the middle of its inner margin. At this point, the suture turns inward, across the end of the main branch of the premaxillary, and then obliquely backward, along the posterior end of its palatine plate. The median suture is continued backward, separating the maxillaries, to a point nearly opposite the middle of the penultimate molar, where the maxillaries join the palatines. The maxillo-palatine suture is at first transverse, extending across the palate nearly to the alveolar border of the maxillary, and is then continued backward near this border, and around behind the last molar, whence it turns outward, and ascends the side of the skull in the orbital region.

The palatal surface of each maxillary is deeply excavated in front between the canines, along the diastema, and as far back as the second or third premolar; but on the median line these bones meet in a sharp ridge, nearly on a level with the outer opposite border of the maxillaries.

FIG. 22.

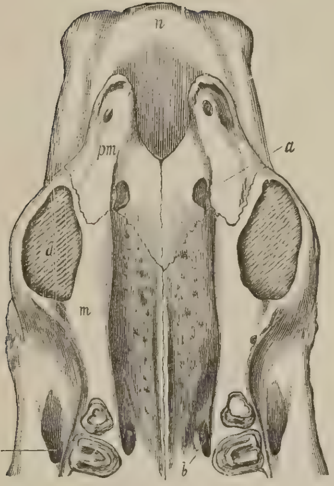


FIG. 25.

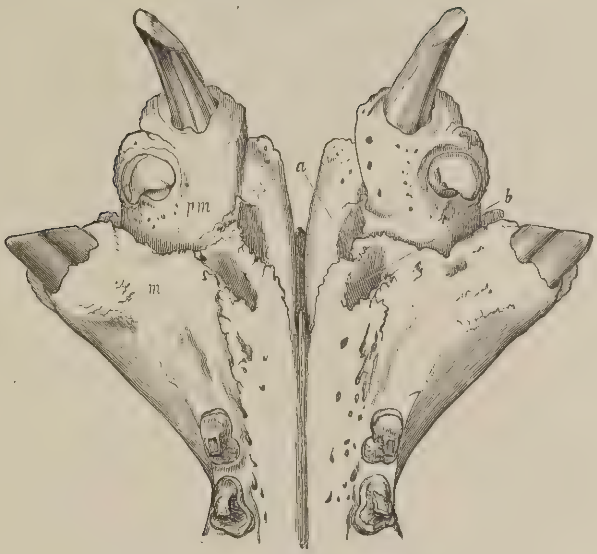


FIG. 23.

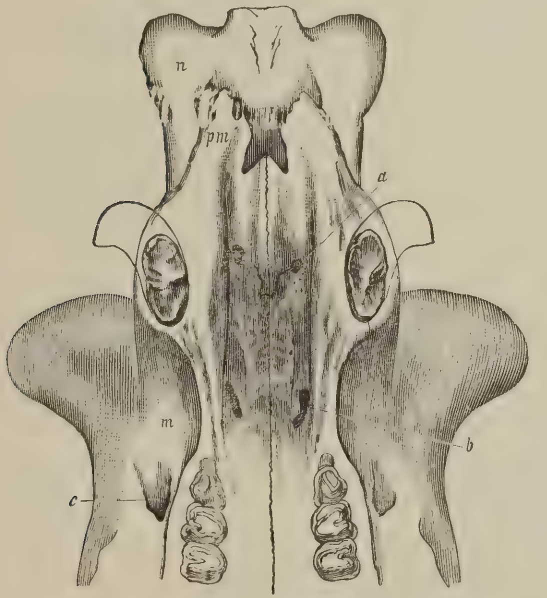


FIG. 24.

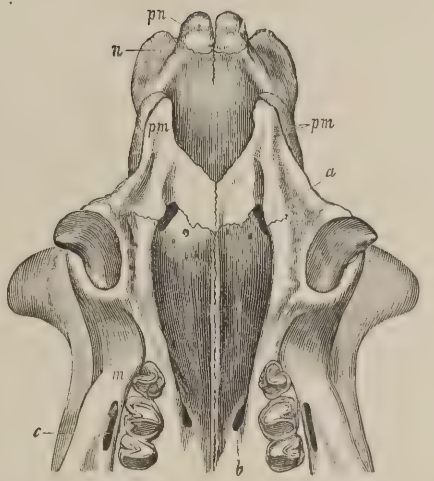


FIGURE 22.—Anterior part of palate of *Dinoceras laticeps*, Marsh (No. 1039).
FIGURE 23.—Anterior part of palate of *Tinoceras ingens*, Marsh (No. 1041).
FIGURE 24.—Anterior part of palate of *Tinoceras pugnax*, Marsh (No. 1044).
FIGURE 25.—Anterior part of palate of *Hippopotamus amphibius*, Linnæus.

a. anterior palatine foramen; *b.* palato-maxillary foramen; *c.* antorbital foramen; *d.* alveole of canine; *m.* maxillary bones; *n.* nasal bones; *pm.* premaxillary bones; *pn.* prenasal ossicles.

All the figures are one-fifth natural size.

The bony palate is thus deeply excavated on each side in the region of the diastema, and near the posterior part of each excavation on either side is situated a large foramen, which may be called the palato-maxillary foramen. This foramen is shown in Plate V, and also in figures 22–24, *b*, page 25. The same foramen is seen, also, in the hippopotamus.

Fig. 27.

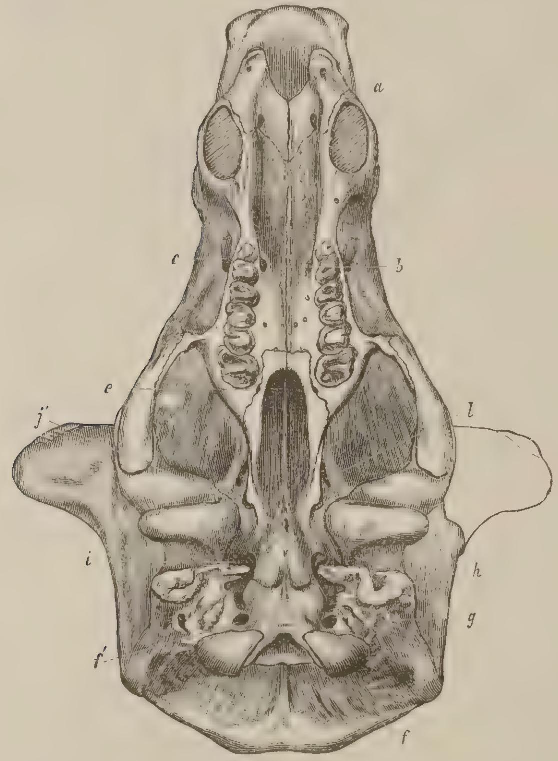


Fig. 26.

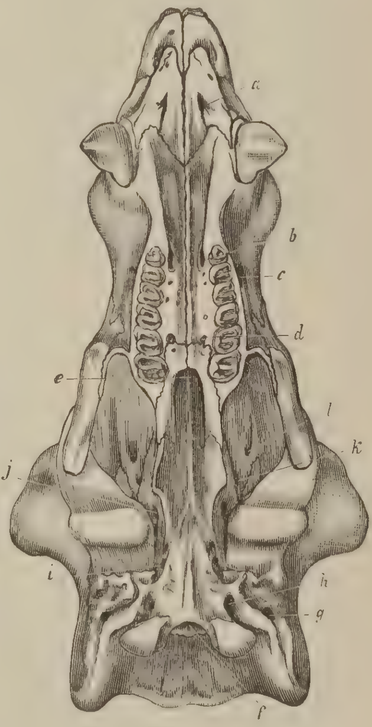


Figure 26.—Skull of *Dinoceras mirabile*, Marsh (No. 1036); seen from below.
Figure 27.—Skull of *Dinoceras laticeps*, Marsh (No. 1039); same view.

a. anterior palatine foramen; *b.* palato-maxillary foramen; *c.* antorbital foramen; *d.* posterior palatine foramen; *e.* posterior nares; *f.* foramen magnum; *f′.* occipital foramen; *g.* stylomastoid foramen; *h.* foramen lacerum posterius; *i.* vascular foramen in basisphenoid; *j.* posterior opening of alisphenoid canal; *k.* anterior opening of alisphenoid canal; *l.* optic foramen.

Both figures are one-eighth natural size.

The palatine surface of the maxillary bone is perforated with small foramina, along the line of the enclosed canal, as in the hippopotamus, evidently for the transmission of blood-vessels and nerves to the gums and surface of the palate.

The maxillary bones contain the sockets of all the upper teeth. The socket for the canine is a large and deep cavity, elongate-oval in section, and extending upward and backward to the posterior part of the base of the large maxillary protuberance. The outer surface of the maxillary

Fig. 28.

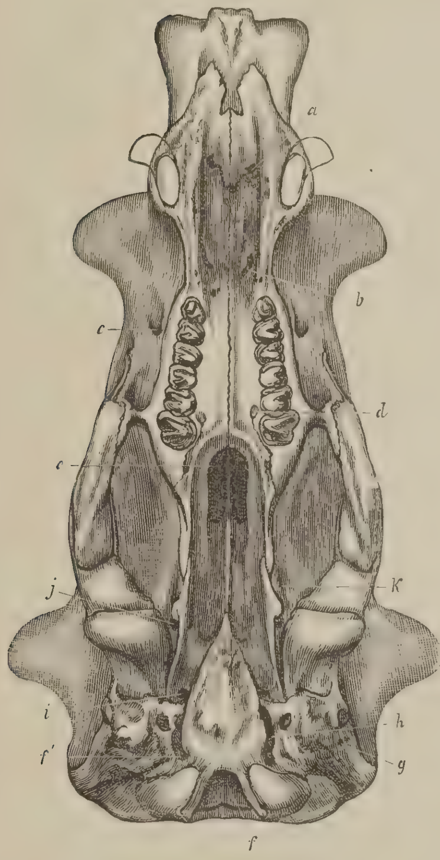


Fig. 29.

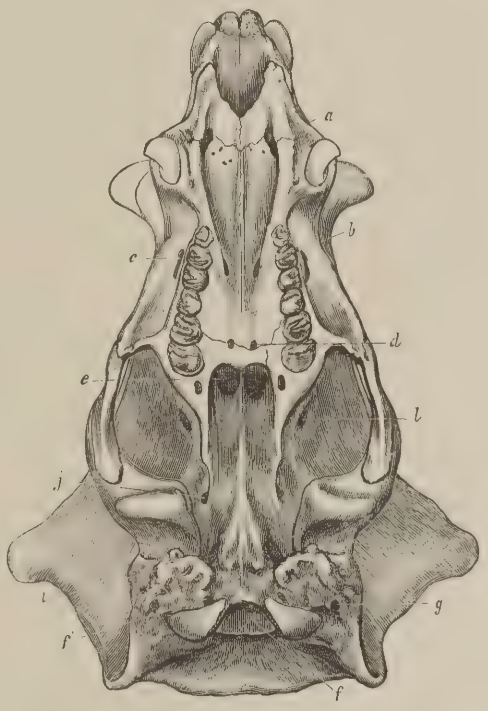


Figure 28.—Skull of *Tinoceras ingens*, Marsh; seen from below.
Figure 29.—Skull of *Tinoceras pugnax*, Marsh; same view.

a. anterior palatine foramen; *b.* palato-maxillary foramen; *c.* antorbital foramen; *d.* posterior palatine foramen; *e.* posterior nares; *f.* foramen magnum; *f′.* occipital foramen; *g.* stylo-mastoid foramen; *h.* foramen lacerum; *i.* vascular foramen in basisphenoid; *j* posterior opening of alisphenoid canal; *k.* anterior opening of alisphenoid canal; *l.* optic foramen.

Both figures are one-eighth natural size.

bone is swollen by this socket, so as to present, in the males at least, a prominent rounded ridge on the side of the face. The alveoli for the premolar and molar series of teeth are similar to each other, each presenting three pits for the reception of roots, viz: an inner large pit, and two outer small ones. Over these, the bone is thin, as is usual on the buccal surface of the maxillary.

Behind and above the posterior molar teeth, in the orbital region of the skull, the maxillary bone presents several fissures, or foramina, close to, or in, the suture with the palatine. The first of these may be indistinct, or of different shape on the opposite sides, and is just back of the last molar, as shown in the skull of *Dinoceras lucare*, on Plate IX, figure 2. In *Dinoceras mirabile* (number 1036), three such fissures are situated on the right side of the skull, in or near the maxillo-palatine suture, back of the orbit. One or more of these apertures appear to be the posterior openings of the posterior palatine foramina, an arrangement similar to that seen in the hippopotamus.

The Palatine Bones.

The palatine bones form only a small part of the bony palate in *Dinoceras*. The palato-maxillary suture in *Dinoceras mirabile* (number 1036) is nearly opposite the middle of the second molar, and about 20^{mm} in front of the posterior border of the bony palate, (Plate V). It is at first nearly transverse to the palate, then runs backward around the last molar, and turns upward into the orbital region, where it cannot be followed with certainty. Posteriorly, the palatine is in contact with the pterygoid, and the pterygoid plate of the alisphenoid. On the median line of the palate, the suture between the opposite palatines is obliterated.

The palatines continue the lateral walls of the posterior nasal cavities considerably behind the last molar, and these walls are still further extended by the pterygoid bones.

The Pterygoid Bones.

The pterygoid bones in *Dinoceras mirabile* (number 1036), are applied to the inner surface of the palatines, and to the pterygoid plates of the alisphenoid (Plate V, *pt*). They appear to unite on the median line in the roof of the posterior nares, but the suture is not distinct. The suture with the palatine is oblique, and that with the alisphenoid can be traced upward beneath the zygomatic arch.

The lower margin of the pterygoid is thickened, and nearly straight. The posterior margin is thinner, and moderately curved.

Fig. 30.

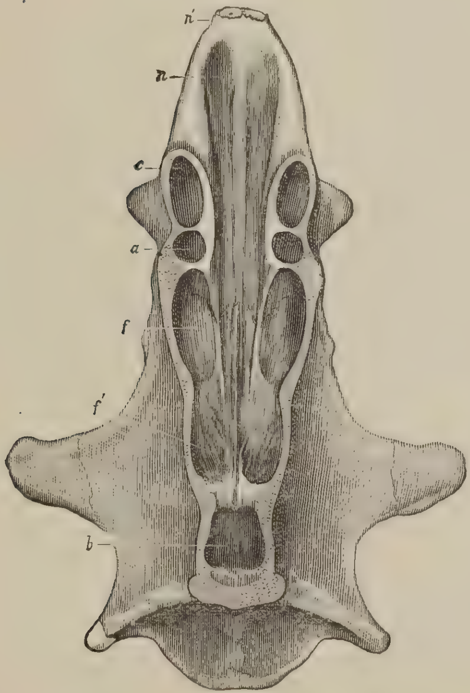


Fig. 31.

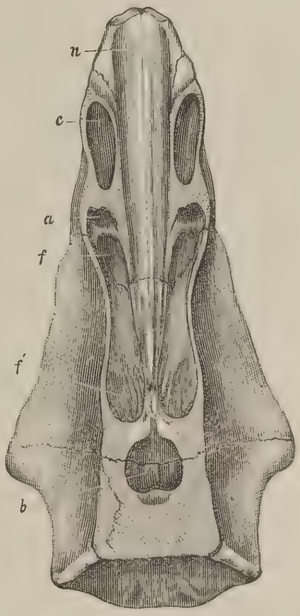


Figure 30.—Horizontal section of skull of *Tinoceras crassifrons*, Marsh (No. 1236).
Figure 31.—Horizontal section of skull of *Dinoceras distans*, Marsh (No. 1601).

a cavity behind base of canine tooth; *b.* brain-cavity; *c.* alveole of canine tooth; *f.* anterior olfactory chamber; *f'.* posterior olfactory chamber; *m'.* maxillary protuberance; *n.* nasal bones; *n'.* nasal protuberance; *p'.* parietal protuberances.

Both figures are one-eighth natural size.

In the skull of *Tinoceras ingens* (number 1041), the palate is only slightly excavated in its anterior part, and the palato-maxillary foramina are brought forward in front of the entire series of molar teeth, instead of being situated nearly opposite the second premolar. The palate between the whole series of molar teeth is nearly flat. The foramen in the maxillo-palatine suture behind the last molar is large and conspicuous, especially on the left side. These foramina are shown in figure 28, page 27.

FIG. 32.

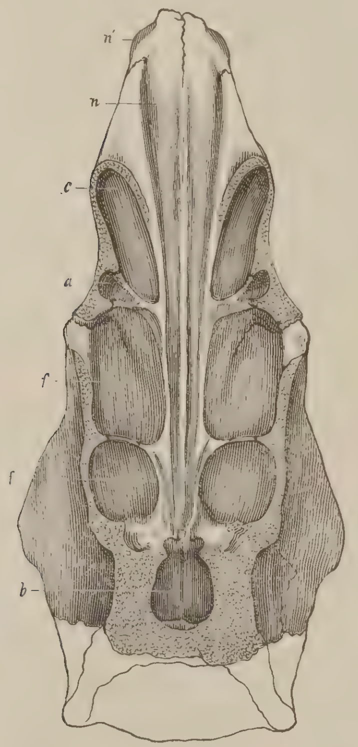


FIG. 33.

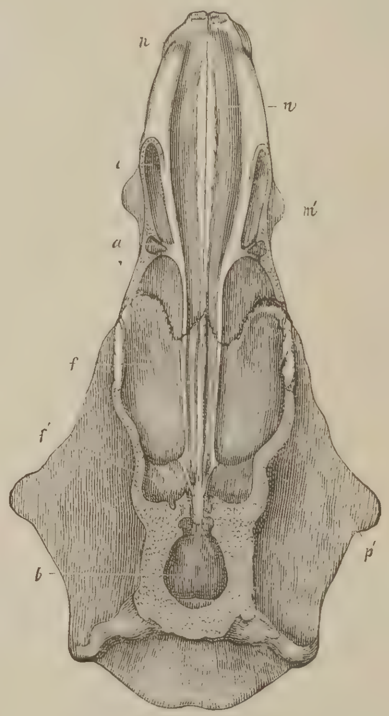


FIGURE 32.—Horizontal section of skull of *Tinoceras hians*, Marsh (No. 1499).

FIGURE 33.—Horizontal section of skull of *Dinoceras laticeps*, Marsh (No. 1202), female.

a. cavity behind base of canine tooth; *b*. brain-cavity; *c*. alveole of canine tooth; *f*. anterior olfactory chamber; *f'*. posterior olfactory chamber; *m'*. maxillary protuberance; *n*. nasal bones; *n'*. nasal protuberances; *p'*. parietal protuberances.

Both figures are one-eighth natural size.

In the type of *Tinoceras grande* (number 1040), the maxillo-palatine foramen is behind the beginning of the molar series, and the excavation of the palatal region also extends behind the first premolars.

In the type of *Dinoceras*, the palatine fossa of the posterior nares is roofed over, so that the passage from the palate into the large nasal cavities above leads forward and upward, as shown indistinctly in figure 26, *e*, page 26. In *Tinoceras ingens* and *Tinoceras pugnax*, the roof of this fossa is excavated in front by a pair of oval apertures, and through these the posterior nares open directly upward, as represented in figures 28 and 29, *e*, on page 27. The existing perissodactyls, the horse, the tapir, and rhinoceros, have the same type of palate. In *Uintatherium*, the structure of this portion of the skull has not yet been determined with certainty.

FIG. 34.

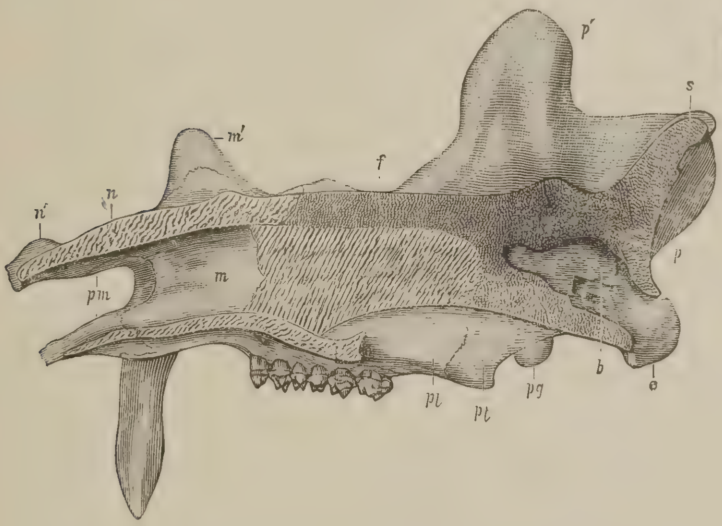


FIG. 35.

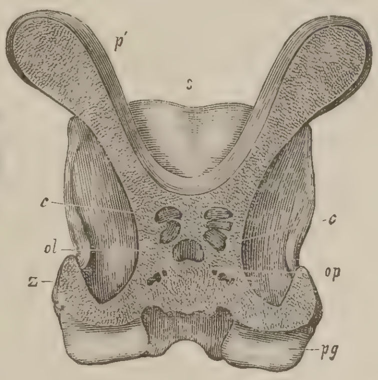


FIGURE 34.—Vertical median longitudinal section of skull of *Dinoceras mirabile*. Marsh.
FIGURE 35.—Vertical transverse section of skull of *Dinoceras mirabile*.

b. brain-cavity; *c.* cavities in cranial walls; *f.* frontal bone; *m.* maxillary bone; *m′.* maxillary protuberance; *n.* nasal bone; *n′.* nasal protuberance; *o.* occipital condyle; *ol.* olfactory lobes of brain; *op.* optic foramen; *p.* parietal bone; *p′.* parietal protuberance; *pg.* post-glenoid process; *pl.* palatine bone; *pm.* premaxillary bone; *pt.* pterygoid bone; *s.* supra-occipital crest; *z.* zygomatic process of squamosal.

Both figures are one-eighth natural size.

These palatine characters of the *Dinocerata* are important, but unfortunately they can be made out only in skulls unusually well preserved. The value of these characters in classification will be discussed in a subsequent chapter

The Vomers.

The vomers in the *Dinocerata* do not appear upon the surface of the palate. They are narrow bones, closely united, and deeply concave upon their upper surface. They are wedged in between the palatine plates of the maxillaries, and in old animals are closely united with them.

The groove formed by the upper concave surfaces of the vomers is filled by the turbinal bones, which are well developed.

The following are the principal dimensions of three of the skulls described in the present chapter. Measurements of others will be found in the Synopsis at the end of the volume:

Measurements of Skull. (*Dinoceras mirabile*, No. 1036.)

	m.
Total length of skull from nasals to occipital crest,	0.76
Total length, from premaxillaries to occipital condyles,	0.66
Greatest transverse diameter, through parietal protuberances,	0.385
Greatest transverse diameter, through occipital crest,	0.26
Greatest transverse diameter, through maxillary protuberances,	0.205
Least transverse diameter, behind maxillary protuberances,	0.155
Greatest transverse diameter, through zygomatic arches,	0.285
Greatest transverse diameter, through post-glenoid processes,	0.25
Length of palate, from end of premaxillaries to posterior nares,	0.35
Length of palatine bone, on median line,	0.030
Length of maxillary bone, on median line,	0.185
Width of palate, between last molars,	0.050
Width of palate, between first molars,	0.065
Width of palate, between first premolars,	0.050
Width of palate, across diastema,	0.07
Width of palate, between canines,	0.105
Antero-posterior diameter of zygomatic fossa,	0.165
Transverse diameter of zygomatic fossa,	0.08
Distance from top of parietal protuberance to end of post-glenoid process,	0.37
Distance from top of maxillary protuberance to end of canine,	0.415
Vertical diameter of foramen magnum,	0.051
Transverse diameter of foramen magnum,	0.055

Measurements of Skull. (*Tinoceras ingens*, No. 1041.)

	m.
Total length of skull from nasals to occipital crest,	0.87
Total length, from premaxillaries to occipital condyles,	0.815
Greatest transverse diameter, through parietal protuberances,	0.47
Greatest transverse diameter, through parietal angles of crest,	0.33
Greatest transverse diameter, through maxillary protuberances,	0.35
Least transverse diameter, behind maxillary protuberances,	0.21
Greatest transverse diameter, through zygomatic arches,	0.37
Greatest transverse diameter, through post-glenoid processes,	0.30
Length of palate, from end of premaxillaries to posterior nares,	0.40
Width of palate, between last molars,	0.064
Width of palate, between first molars,	0.065
Width of palate, between first premolars,	0.056
Width of palate, across diastema,	0.09
Width of palate, between canines,	0.10
Antero-posterior diameter of zygomatic fossa,	0.19
Transverse diameter of zygomatic fossa,	0.08
Distance from top of parietal protuberance to end of post-glenoid process,	0.52
Vertical diameter of foramen magnum,	0.075
Transverse diameter of foramen magnum,	0.045

Measurements of Skull. (*Tinoceras pugnax*, No. 1044.)

	m.
Total length of skull from nasals to occipital crest,	0.77
Total length, from premaxillaries to occipital condyles,	0.665
Greatest transverse diameter, through parietal protuberances,	0.425
Greatest transverse diameter, through parietal angles of crest,	0.305
Greatest transverse diameter, through maxillary protuberances,	0.255
Least transverse diameter, behind maxillary protuberances,	0.19
Greatest transverse diameter, through zygomatic arches,	0.34
Greatest transverse diameter, through post-glenoid processes,	0.28
Length of palate, from end of premaxillaries to posterior nares,	0.33
Width of palate, between last molars,	0.084
Width of palate, between first molars,	0.084
Width of palate, between first premolars,	0.056
Width of palate, across diastema,	0.096
Width of palate, between canines,	0.132
Antero-posterior diameter of zygomatic fossa,	0.12
Transverse diameter of zygomatic fossa,	0.096
Distance from top of parietal protuberance to end of post-glenoid process,	0.37
Distance from top of maxillary protuberance to end of canine, about	0.48
Vertical diameter of foramen magnum,	0.050
Transverse diameter of foramen magnum,	0.075

CHAPTER II.

THE LOWER JAW.

(Plates VIII, XII, XIII, XIX, LV, and LVI.)

The lower jaw in *Dinoceras* is as remarkable as the skull. Its most peculiar feature in the male is a massive decurved process on each ramus, extending downward and outward. These long pendent processes were apparently to protect the upper canine tusks, which would otherwise be very liable to be broken (Plate XIII, figures 1 and 2, *p*). Indications of similar processes are seen in *Smilodon*, and in some other extinct carnivors with long canines.

In *Dinoceras mirabile* (number 1212), the process is concave from above downward on its external surface, and its lower extremity is somewhat thin, and narrowed longitudinally. In *Dinoceras laticeps* (Plate XIII, figures 1 and 2, *p*), this process is more massive, and more rounded below.

In the female, this process is much reduced in size, but is quite sufficient to protect the diminutive tusk, which overlaps it.

With the exception of these processes, the lower jaw is comparatively small and slender. The symphysis is completely ossified, and deeply excavated above.

Another remarkable feature in the lower jaw of the *Dinocerata* is the posterior direction of the condyles, hitherto unknown in Ungulates (Plate

VIII, figure 1, *cd*). The position of the condyles was evidently necessitated by the long upper tusks, since with the ordinary ungulate articulation the mouth could not have been fully opened. The low position of the condyle, but little above the line of the teeth, is also a noteworthy character. In some Marsupials and Insectivors, the condyle has the same position as in the *Dinocerata*, but in no other Ungulates, living or extinct, has this position been observed.

FIG. 36.

FIG. 37.

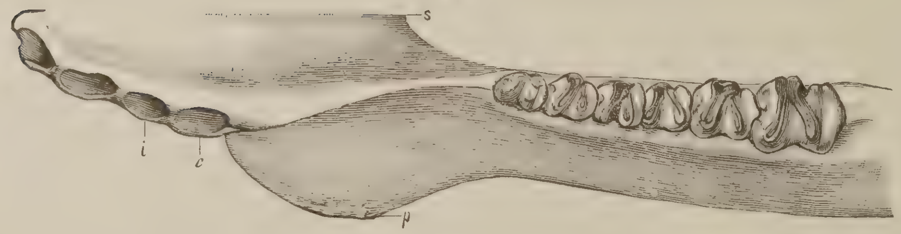


FIGURE 36.—Lower jaw of *Tinoceras annectens*, Marsh (No. 1043); seen from the left.
FIGURE 37.—The same jaw, seen from above.

c. alveole of lower canine; *d.* diastema; *i.* alveole of incisor; *m.* mental foramen; *p.* process for protection of canine tusk; *s.* symphysis.

Both figures are one-fourth natural size.

In *Dinoceras laticeps* (Plates XII and XIII), the entire lower jaw is more massive than in *Dinoceras mirabile*. The angle of the jaw is stouter, and distinctly inflected (Plate XIII, figure 2, *a*.)

The coronoid process of the lower jaw in *Dinoceras* is large and elevated, somewhat curved backward, and pointed above (Plate VIII, figure 1, *cr*). The angle of the jaw is rounded in outline, and projects downward somewhat below the main portion of the ramus. The dental foramen is large, and bounded above by a ridge, which extends upward and backward to the condyle. The mental foramen is of moderate size, and situated near the base of the anterior pendent process.

FIG. 38.

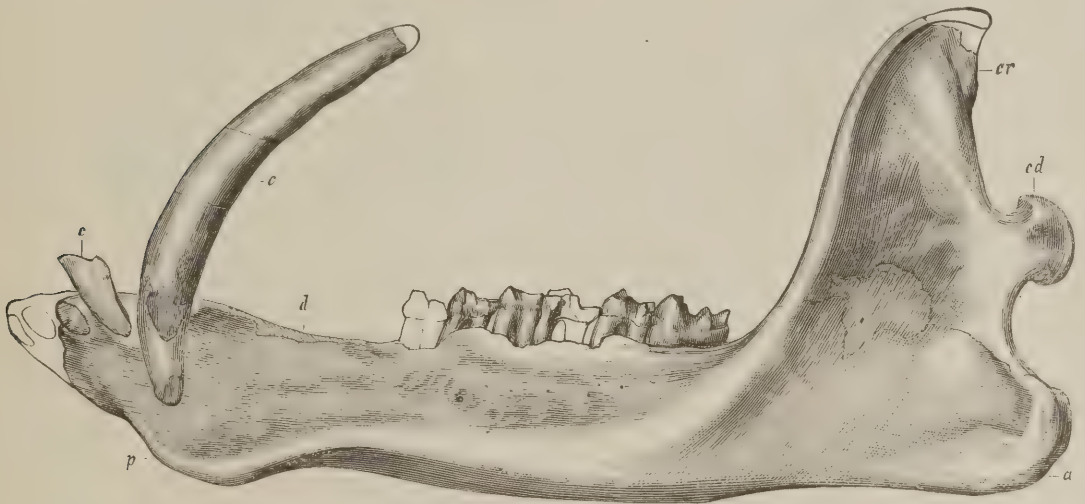


FIGURE 38.—Lower jaw with upper canine in position of *Tinoceras longiceps*, Marsh (No. 1256), female; seen from the left.

a. angle of jaw; *c*, upper canine tooth in its natural position; *c'*. lower canine tooth; *cd.* condyle; *cr.* coronoid process; *d.* diastema; *p.* process for protection of canine tusk.

One-fourth natural size.

In the genus *Tinoceras*, the same general characters of the lower jaws are seen. In the male, the pendent process is large and elongate, but less massive than in the genus *Dinoceras*, and its lower outline less regularly rounded (Plate XIX, figure 1, *cp*). This corresponds with the position of the large upper canine tusk, which it protects.

In the female of *Tinoceras*, the pendent process is much reduced, its size in all cases corresponding to the size of the canine tusk above. In the female of *Tinoceras longiceps* (figure 38, above), the lower jaw is remarkably long and slender, and the pendent process nearly obsolete.

That the same relation in size between the tusk and process below it holds equally in both the genera *Dinoceras* and *Tinoceras*, is conclusively shown by various specimens in the Yale Museum.

FIG. 39.

FIG. 40.

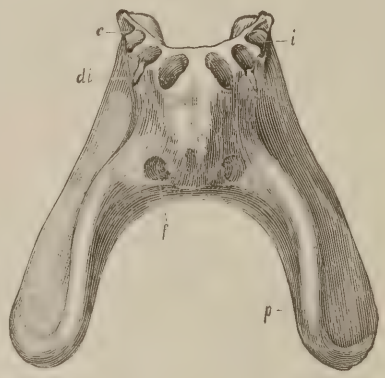


FIGURE 39.—Lower jaw of *Dinoceras mirabile*, Marsh (No. 1251); seen from the left.
FIGURE 40.—The same jaw; seen from the front.

c. alveole of canine; *f.* anterior foramen; *di.* deciduous incisor; *i.* alveole of incisor; *m.* mental foramen; *p.* process for protection of tusk.

Both figures are one-fourth natural size.

In the genus *Dinoceras*, there are three incisor teeth, and a small incisiform canine on each side forming a continuous series at the front extremity of the lower jaw. These are all of moderate size, and inclined well forward, as in the ruminant mammals. Behind this series, and immediately over the dependent process, is a long diastema (Plate VIII, figure 1, *d*). Further back, there are three premolars, and three molars, forming together a close series. This is the dentition, essentially, in the lower jaw of both *Dinoceras* and *Tinoceras*, and will be described more fully in the following chapter.

In a lower jaw found near the locality of the type of *Uintatherium robustum*, and here referred to that genus, there are four premolars instead of three. The first premolar, wanting in *Dinoceras* and *Tinoceras*, is of small size, and is placed just behind the lower canine. It is separated from the second premolar by a diastema, as shown in figures 41 and 42, page 39.

In the present state of knowledge of the *Dinocerata*, this first lower premolar may be regarded as a distinctive feature of the genus *Uintatherium*, the type specimen of which, unfortunately, is too fragmentary for a complete identification of its principal characters.

Fig. 41.

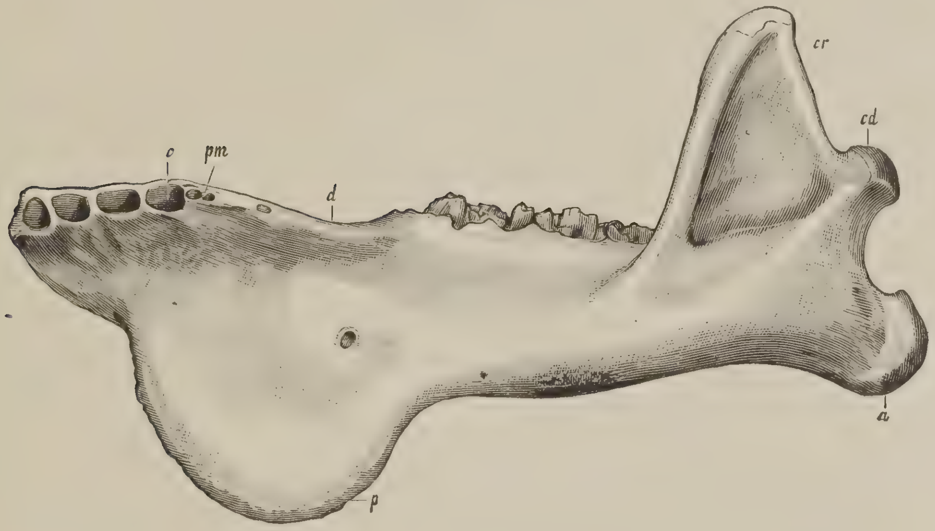


Fig. 42.

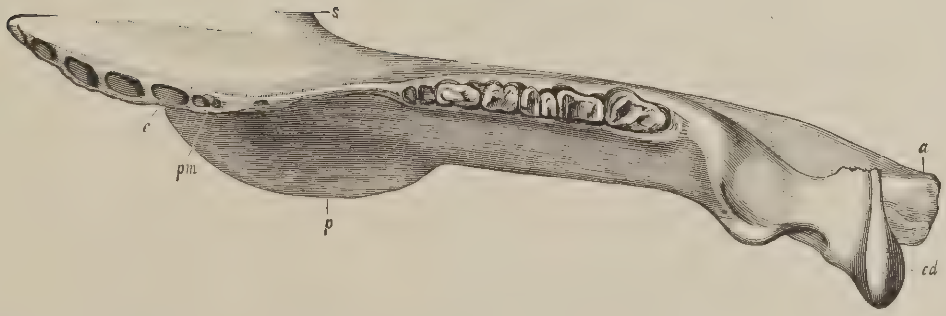


Figure 41.—Lower jaw of *Uintatherium segne*, Marsh (No. 1194); seen from the left.
Figure 42.—The same jaw; seen from above.

a. angle; *c.* alveole of canine; *cr.* coronoid process; *cd.* condyle; *d.* diastema; *p.* process for protection of tusk; *pm.* alveole of premolar

Both figures are one-fourth natural size.

The principal dimensions of three of the lower jaws described in this chapter are as follows:

Measurements of Lower Jaw. (*Dinoceras laticeps*, No. 1039.)

	m.
Greatest length of ramus,	0.54
Extent of symphysis,	0.18
Height of coronoid process from bottom of ramus,	0.235
Depth of ramus at last molar,	0.09
Depth of ramus at tusk process,	0.185
Extent of diastema,	0.10
Extent of molar series,	0.18
Greatest width across condyles,	0.295
Transverse diameter of condyle,	0.087
Vertical diameter of condyle,	0.048

Measurements of Lower Jaw. (*Uintatherium segne*, Marsh, No. 1194.)

	m.
Greatest length of ramus,	0.49
Extent of symphysis,	0.165
Height of coronoid process from bottom of ramus (approximate),	0.19
Depth of ramus at last molar,	0.075
Depth of ramus at tusk process,	0.17
Extent of molar series (functional),	0.145
Transverse diameter of condyle,	0.076
Vertical diameter of condyle,	0.040

Measurements of Lower Jaw. (*Tinoceras longiceps*, Marsh, No. 1256, female.)

	m.
Greatest length of ramus (approximate),	0.57
Extent of symphysis,	0.185
Height of coronoid process from bottom of ramus,	0.26
Depth of ramus at last molar,	0.084
Depth of ramus at tusk process,	0.10
Extent of diastema,	0.145
Extent of molar series,	0.175
Transverse diameter of condyle,	0.070
Vertical diameter of condyle,	0.045

CHAPTER III.

THE TEETH.

(Plates I–V, VII–X, XII–XIX, LV and LVI.)

The teeth of the *Dinocerata* constitute one of their most interesting features, differing widely in form and dentition from most of the other *Ungulata*.

In the genus *Dinoceras* the dentition is represented by the following formula:

$$\text{Incisors } \frac{0}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{3}{3}, \text{ molars } \frac{3}{3} = 34.$$

So far as now known, the same formula applies equally well to the genus *Tinoceras*.

In *Uintatherium*, the dentition is apparently as follows:

$$\text{Incisors } \frac{0}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{3}{4}, \text{ molars } \frac{3}{3} = 36.$$

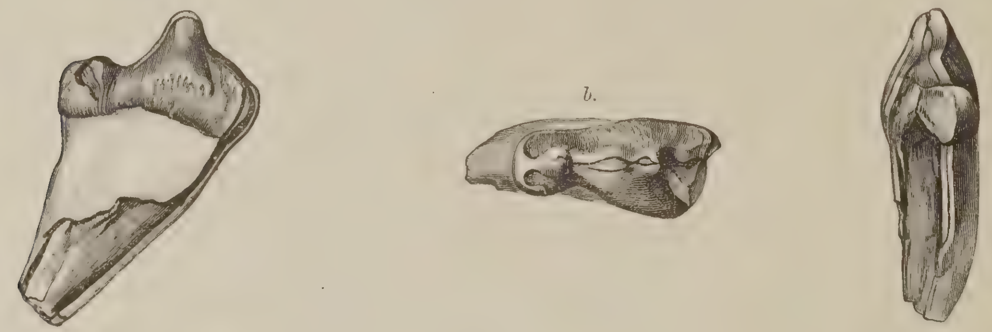
The Incisors.

In none of the *Dinocerata* have any upper incisors been found, even in the youngest specimens. The premaxillary bones appear to be entirely edentulous, although in some specimens, especially in *Dinoceras laticeps* (number 1039), there are shallow depressions at irregular intervals that strongly suggest the probability of embryonic teeth in very young, or fœtal individuals. A fortunate discovery in the future may, perhaps, settle this point.

6

In the lower jaws of all the known *Dinocerata*, there are three well-developed incisors on each side. They are inserted, each by a single root, and are procumbent, all directed well forward. Their inner surfaces

a. FIG. 43. c.



a. FIG. 44. c.

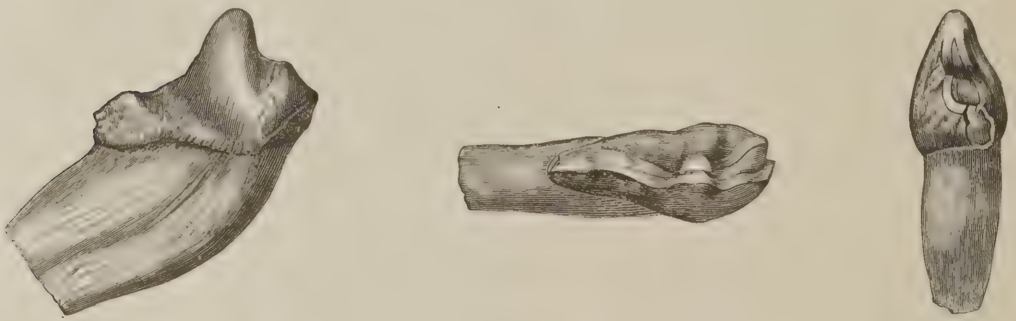


FIG. 45. c.

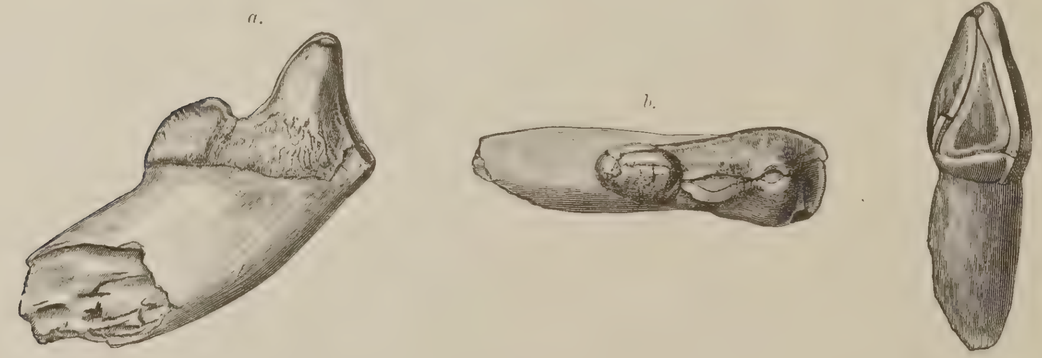


FIGURE 43.—Incisor of *Dinoceras mirabile*, Marsh (No. 1491).
FIGURE 44.—Incisor of *Dinoceras mirabile* (No. 1492).
FIGURE 45.—Incisor of *Dinoceras mirabile* (No. 1490).
a. side view; *b.* top view; *c.* antero-posterior view.

All the figures are of natural size.

continue the deep groove on the upper part of the lower jaw, above the symphysis. The position of the sockets for these teeth in *Dinoceras* is shown in Plates XII and XIII, and the form of the teeth, in Plate VIII, figure 1. The crowns of these incisors are covered with enamel, and the special features of both crown and root are shown in figures 43–45, page 42.

In the genus *Tinoceras*, the incisors are similar in form, but have a less inclined position, as indicated in Plate XIX, figure 1.

Fig. 46. Fig. 47. Fig. 48.

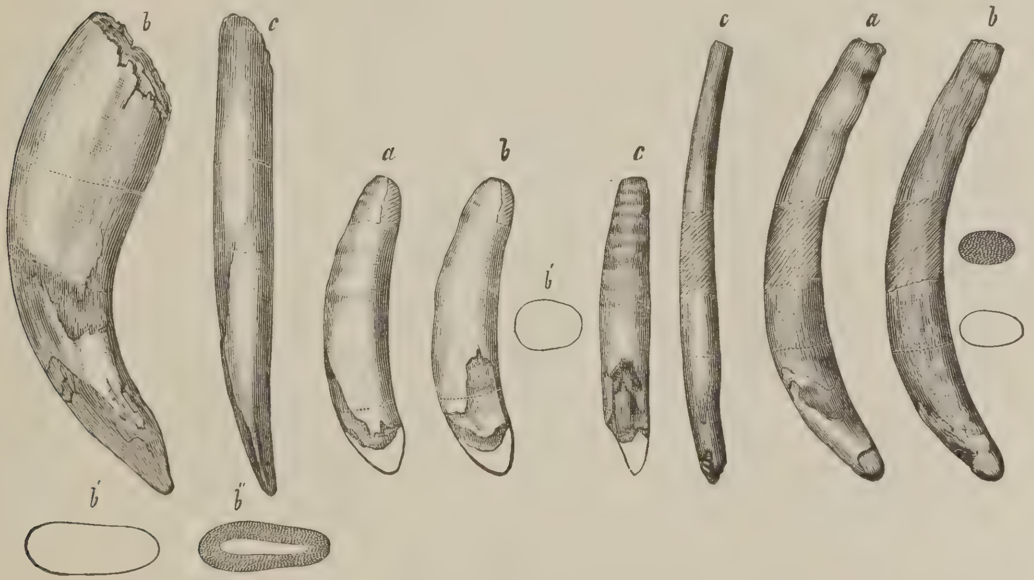


FIGURE 46.—Upper canine of *Dinoceras lucare*, Marsh (No. 1038); male. *b.* lateral view, inner surface; *b′.* outline of section of tooth; *b″.* section of tooth showing pulp cavity; *c.* front view of tooth.

FIGURE 47.—Upper canine of *Dinoceras laticeps*, Marsh (No. 1202); female. *a.* outer surface; *b.* inner surface; *b′.* outline of section; *c.* front view.

FIGURE 48.—Upper canine of *Tinoceras longiceps*, Marsh (No. 1256); female. *a.* outer surface; *b.* inner surface; *c.* front view of tooth.

The dotted line on the teeth marks the position of the alveolar border, below which the tusk was exposed.

All the figures are one-fourth natural size.

The Canines.

The superior canines of *Dinoceras* are long, recurved, trenchant tusks. The crown is covered with enamel, and the root extends upward into the base of the maxillary protuberance, or horn-core. When the animal is

young, these tusks grow from a persistent pulp, but in old age the cavity becomes nearly closed. In the male, these tusks are large and powerful, and extend downward nearly or quite to the extremity of the pendent process of the lower jaw.

Fig. 49.

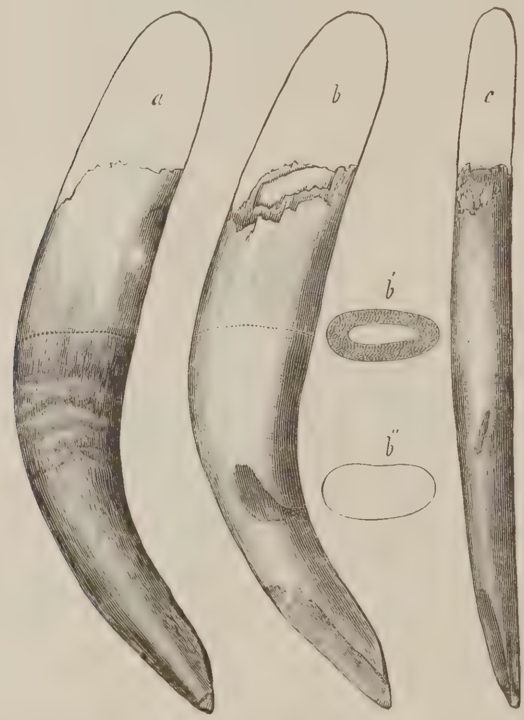


Fig. 50.

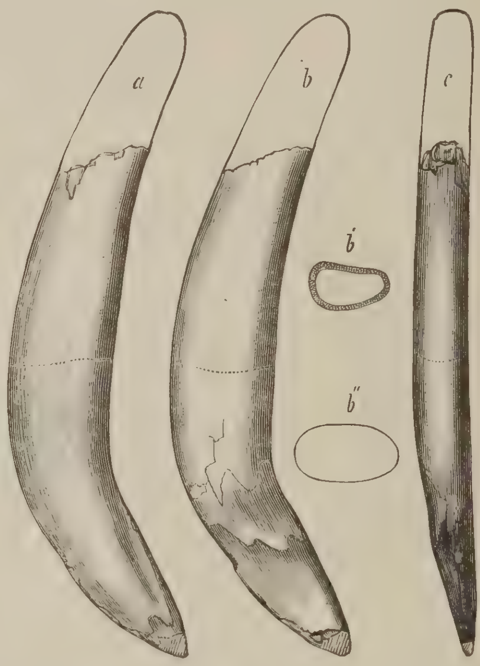


Figure 49.—Upper canine of *Tinoceras grande*, Marsh (No. 1040); male.
Figure 50.—Upper canine of *Dinoceras laticeps*, Marsh (No. 1222); male.

a. lateral view showing outer surface; *b.* inner surface; *b'. b''.* sections; *c.* front view.

The dotted line on the teeth marks the position of the alveolar border, below which the tusk was exposed.

All the figures are one-fourth natural size.

In *Dinoceras mirabile* (number 1036), the canine tusks are oval in section, where they emerge from the jaw, then become somewhat constricted, before expanding into a wide, thin, lanceolate extremity, as shown in Plate I. On the outer surface of these tusks, there is a distinct ridge in the lower half exposed, giving there a subtriangular, or bayonet-like form.

In *Dinoceras lucare*, the upper canines are not constricted, but taper to the lower end, which has, also, a bayonet form (Plate IX, figure 1, *c*).

FIG. 51.

FIG. 52.

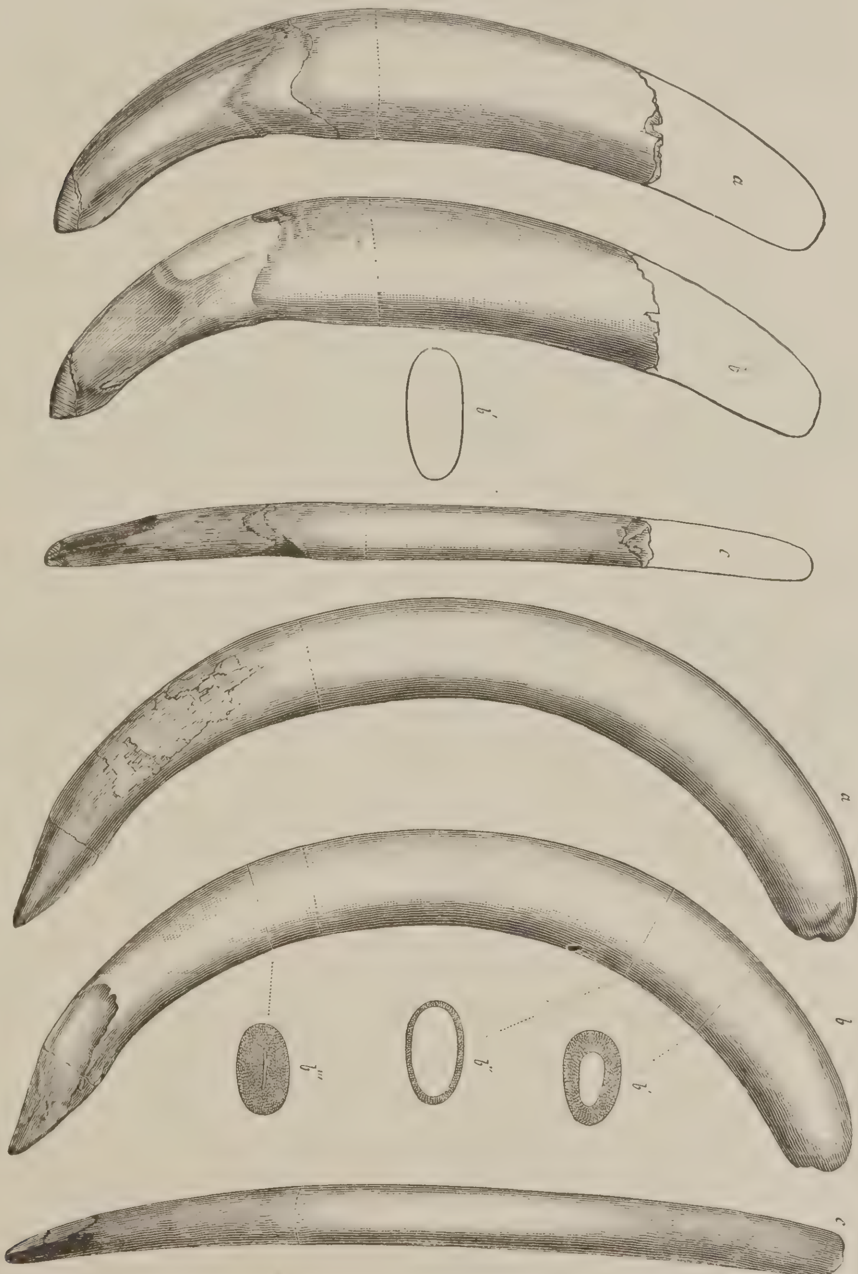


FIGURE 51.—Upper canine of *Tinoceras ingens*, Marsh (No. 1043); male.
FIGURE 52.—Upper canine of *Tinoceras pugnax*, Marsh (No. 1041); male.
a. lateral view, showing outer surface; *b*. inner surface; *b′*. *b″*. *b‴*. sections of tooth; *c*. front view.
All the figures are one-fourth natural size.

In the female of *Dinoceras*, the upper canines are small and slender, and protrude but little below the jaw (Plate XIV, figure 1, *c*).

In *Tinoceras*, the upper canines are much more curved than in *Dinoceras*, and the end of the root, instead of being inserted in the base of the maxillary horn-core, starts well back of it, so that the general direction of this elevation is nearly at right angles to the tusk.

The general form of the upper canine tusks in the *Dinocerata* is shown in figures 49–52, on pages 44 and 45.

In the lower jaw of *Dinoceras*, the canine is very small, and very similar in form to the incisors, which it adjoins (Plate VIII, figure 1, *c*). The same is true in the genus *Tinoceras*, where the lower canine, as well as the incisors, has a more erect position than in *Dinoceras*.

The Upper Premolars.

The crowns of the premolar and molar teeth in *Dinoceras*, and, in fact, in all of the known *Dinocerata*, are remarkably short, with the roots well developed, forming a true brachyodont dentition, as in all early Tertiary ungulates. These teeth are all inserted by three roots, two small ones on the outer side, and a larger one on the inner side.

In the type of *Dinoceras mirabile* (number 1036), the upper molar series is remarkably well preserved. The entire set of premolars and molars is in position, indicating that the animal was fully adult, and yet the amount of wear shown by these teeth is so slight as not to obscure in the least their essential characters.

The form and relative position of the series on the two sides is well shown in Plate VII, figure 2. There are three premolars, and three true molars on each side, forming together a close series. There is, in this skull, no trace of what may be regarded as the first premolar. If present during the immature condition of the animal, it has entirely disappeared. In one specimen of this genus (number 1039), the alveole of this first upper premolar remains, but no other trace of the tooth has been seen.

The first premolar of *Dinoceras mirabile* in place, which would correspond to the second in the complete ungulate dentition, is the

smallest of the present series. Its crown is subtriangular in outline, with the apex in front. The antero-external face is cordate in outline, somewhat concave, with the point below. On the inner side, there is an elevated lobe, somewhat inside of, and separated from, the apex of the external face. On the inner and posterior faces of this premolar, there is a strong basal ridge, which is nearly or quite obsolete on the anterior face.

FIG. 53.

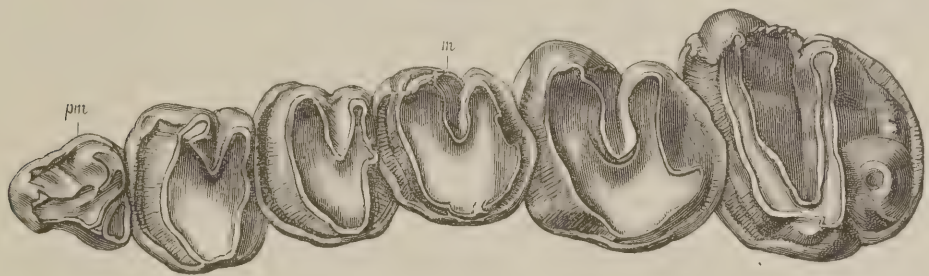


FIG. 54.

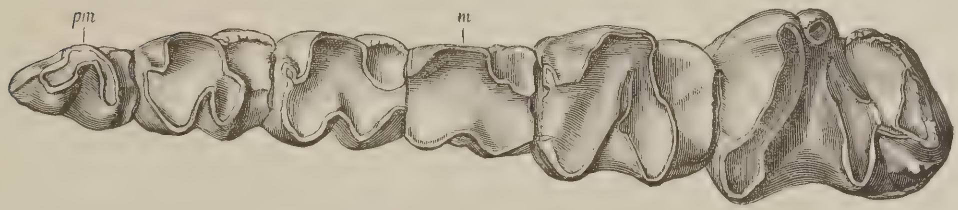


FIGURE 53.—Upper molar series of *Tinoceras stenops*, Marsh (No. 1567); seen from below.
FIGURE 54.—Lower molar series of same specimen; seen from above. *m.* molar; *pm.* premolar.

The figures are three-fourths natural size.

The second upper premolar in this series is much larger than the one last described. The crown is sub-cordate in outline, the apex pointing inward, and somewhat backward. The essential features of the crown consist of two transverse ridges, which meet internally, forming a V-shaped figure. This is the characteristic type of the upper molar series in the *Dinocerata*. The anterior transverse ridge of this tooth has its external extremity somewhat curved backward. This premolar has a well marked basal ridge, entirely surrounding it, although somewhat thin near the middle of the anterior border.

The last upper premolar is very similar to the one just described. Its crown is somewhat more triangular in outline, and the crests of the transverse ridges are straighter. The basal ridge is continued and well developed.

The Upper Molars.

The first true molar is much like the last premolar in general form. It shows by its greater wear that it made its appearance before the last premolar, and in this way its true position in the series is indicated. The anterior transverse crest in this tooth is considerably larger than the posterior crest, and the valley between them is much wider than in the premolars. Behind the posterior crest, moreover, there is, on the inner posterior angle of the crown, a distinct tubercle. This is seen in all of the true molars in *Dinoceras*, and will distinguish them, at once, from premolars of similar general form. The basal ridge of this first molar is well developed, except on the outer side, opposite the outlet of the transverse valley.

The second, or penultimate, upper molar is much larger than the first, but similar in general form. The transverse and antero-posterior diameters of the crown are nearly equal, the former being somewhat greater. The basal ridge is well developed on the posterior side of the crown, and distinct on the internal and anterior faces, but is obsolete on the external face, near the middle.

The last upper molar is much the largest of the series, and the transverse diameter of the crown is considerably greater than the antero-posterior diameter. The anterior crest is larger than the posterior, and considerably curved, with the convexity in front. The posterior crest is nearly straight, but does not join the anterior crest closely at its inner extremity, the two forming a U-shaped figure. Back of the crest, on the posterior, internal border, there are two distinct tubercles in this specimen, as shown in Plate VII, figure 2. The basal ridge is continuous, except between the outer margin of the lateral crests, where it is lost in the depression on this part of the crown.

In *Dinoceras lucare* (number 1038), the upper molar teeth agree with those already described, in their main characters, but as this individual was considerably older than the type of *Dinoceras mirabile*, the teeth show a greater degree of wear, as represented in Plate IX, figure 2.

In the genus *Tinoceras*, the upper molar series is essentially the same in position and structure as in *Dinoceras*.

In *Tinoceras ingens* (number 1041, Plate XVIII, figure 2), the upper series of molar teeth is shown, with a still greater degree of wear than in those above described. In figure 53, page 47, the upper molar series of *Tinoceras stenops* is represented.

The Lower Premolars.

In each ramus of the lower jaw of *Dinoceras*, there is a close series of six teeth, three of which are premolars, and three true molars. These are all inserted each by two roots. This is also true of the genus *Tinoceras*. In these two genera, so far as known, there is no indication of any premolar in front of this series.

The first premolar of the typical ungulate dentition has not been detected in any specimen, young or old, of these genera. In the lower jaw of *Uintatherium*, as this genus is here defined, there were four premolars. The first lower premolar is here present, situated somewhat in front of the others, and but little separated from the lower canine. It was a small tooth, inserted by two roots, and in all probability had no predecessor. The position of this tooth is shown in figures 41 and 42 on page 39.

The second lower premolar, the first of the series in *Dinoceras*, was inserted by two roots. Its crown consists of a large anterior lobe, and a small posterior one. There is a distinct basal ridge on the external surface, which curves around upon the anterior and posterior faces, but is wanting on the inner surface.

The second premolar of this series, representing the third premolar, is considerably larger than the one in front of it, and its crown is less compressed transversely. The anterior and posterior lobes of the crown, especially the former, are here elongated in the transverse ridges, approximating to the V-shaped figure in the corresponding upper premolars. The basal ridge is here on the external face, and curves around behind, so as to enclose the posterior tubercle.

The last lower premolar is very similar in form and size to the one before it, but is somewhat larger. The basal ridge has a similar position.

The Lower Molars.

The first true lower molar is smaller than the last premolar, but is similar in the general form and composition of its crown. It shows a greater degree of wear than the tooth in front of it, thus indicating that it appeared earlier, and is the first of the true molar series. The inner end of the anterior lobe, or crest, has its summit divided by a distinct notch, a trace of which was seen in the corresponding part of the last lower premolar. The basal ridge is distinct on the outer face, and likewise curves around behind the posterior lobe.

The second, or penultimate, lower molar is much larger than the first, and has the transverse ridges much more strongly developed. The anterior one is considerably elevated, and the two do not meet closely on the inner side. The basal ridge is here distinct on the outer surface, and swells in front into a distinct ridge, and behind into a broader crest, or heel.

The last lower molar in *Dinoceras* is much the largest of the series. The anterior crest is nearly straight transversely. The posterior crest is inclined inward and forward, the two meeting on the inner face, forming a distinct V-shaped pattern. The posterior lobe, or heel, is here largely developed, and more distinctly separated by a deep valley, from the two crests just described.

The position and general form of the lower molar teeth in *Dinoceras laticeps* is shown in Plates XII and XIII.

The corresponding teeth in the genus *Tinoceras* are well shown in Plate XIX. The posterior transverse crest of the penultimate and last lower molar have here a distinct tubercle at their inner extremity, at the apex of the typical V-shaped pattern. This is shown especially in figure 2 of Plate XIX. In figure 54, on page 47, the lower molar series of *Tinoceras stenops* is represented.

All of the incisors, canines, and premolars in *Dinoceras* and *Tinoceras* appear to have been preceded by a series of temporary teeth. The incisors, and lower canines sometimes made their appearance before their small predecessors had disappeared. In one specimen, represented in figures 39 and 40, page 38, these immature teeth are seen in place in small cavities in the sides of the alveoles of the permanent dentition.

The lower incisors and their accompanying canines are usually more or less worn. This is due mainly to the food consumed, and in part to the attrition of the upper canines, and, perhaps, also to a heavy, coarse, upper lip. The premaxillaries, being edentulous, probably supported a pad, as in ruminants.

The upper canines show distinct traces of wear on their inner surface near the base, and, also below, near the apex of the crown. This wear is probably due to the action of the agencies just described.

A more difficult problem is presented by the worn surface sometimes seen on the outer face of these tusks, somewhat below the insertion in the jaw, as shown in figure 51, page 45. This is probably due to the wearing action of a heavy upper lip.

The molar teeth in *Dinocerata* appear to resemble more closely the corresponding teeth in the genus *Coryphodon* than those of any other animal. The general dentition, however, is quite distinct. *Coryphodon* has well developed upper incisors, and a medium-sized upper canine, thus differing widely in these features from the *Dinocerata*. The position and size of these teeth in *Coryphodon* are shown in figure 66, page 63. The upper and lower molar series are shown in figures 55 and 56, page 52.

Fig. 55.

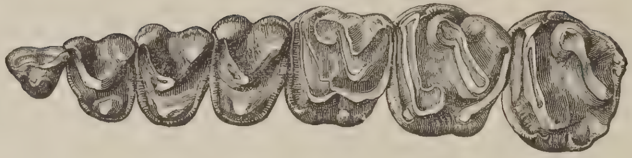


Fig. 56.

Figure 55.—Upper molar series of *Coryphodon hamatus*, Marsh (No. 1334); seen from below.
Figure 56.—Lower molar series of same specimen; seen from above.

Both figures are one-half natural size.

CHAPTER IV.

THE BRAIN.

(Plate VI.)

The brain of the *Dinocerata* is one of the most peculiar features of the group. It is especially remarkable for its diminutive size. It was proportionally smaller than in any other known mammal, recent or fossil, and even less than in some reptiles. It was, indeed, the most reptilian brain in any known mammal. In *Dinoceras mirabile* (number 1036), the entire brain was actually so diminutive that it could apparently have been drawn through the neural canal of all the presacral vertebræ, certainly through the cervicals and the lumbars.

The size of the entire brain in *Dinoceras*, as compared with that of the cranium, is shown in the accompanying cuts, figures 7 and 8, page 15, and figures 57 and 58, page 54. The size of the brain-cavity, and its position in the skull in *Tinoceras*, also, is represented in figure 9, page 16, and figure 67, page 63.

The most striking feature in the brain-cavity itself, is the relatively small size of the cerebral fossa, this being but little larger than the cerebellar portion. This is well shown in Plate VI, the figures of which are drawn from the cast of the brain-cavity of *Dinoceras mirabile*, the type of the genus.

The cerebral hemispheres did not extend at all over the cerebellum or the olfactory lobes. The latter were large, and continued well forward. The hemispheres were probably convoluted, and the sylvian fissure appears to be distinctly marked.

Fig. 57.

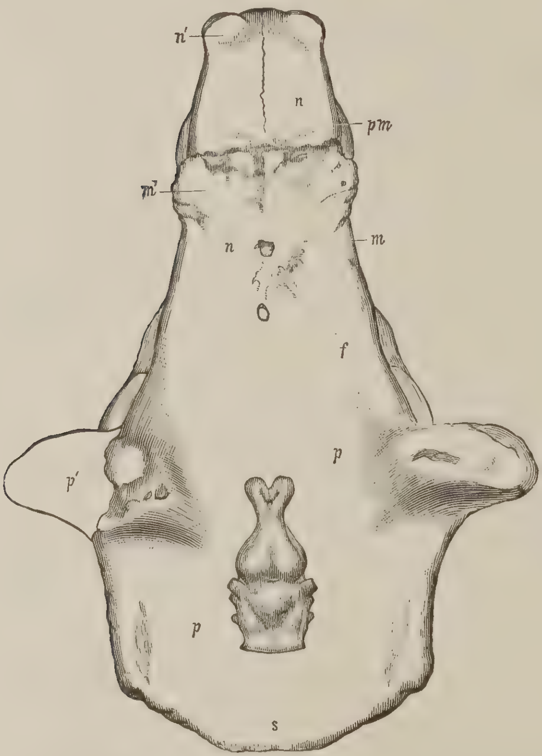


Fig. 58.

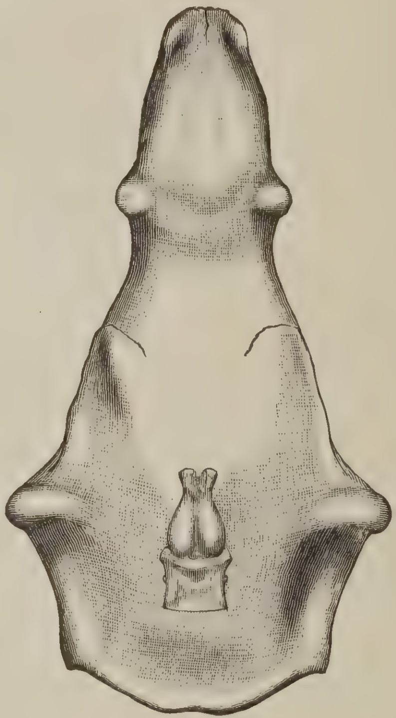


Figure 57.—Skull of *Dinoceras laticeps*, Marsh (No. 1039); male; with brain-cast in position.
Figure 58.—Skull of *Dinoceras laticeps* (No. 1202); female; with brain-cast in position.

f. frontal bone; *m.* maxillary bone; *m'.* maxillary protuberance; *n.* nasal bone; *n'.* nasal protuberance; *p.* parietal bone; *p'.* parietal protuberance; *s.* supraoccipital crest.

Both figures are one-eighth natural size.

The cerebellar fossa is but little larger, transversely, than the medullar canal, and has lateral cavities, which were probably occupied by flocculi. There was a rudimentary tentorial ridge. The pituitary fossa is nearly round, and of moderate depth. There are no clinoid processes.

The Cranial Nerves.

The nerves passing off from the brain were large, and can be made out with reasonable certainty. The olfactory lobes were separated in front by an osseous septum, the position of which is shown distinctly in Plate VI, figure 2

Fig. 59.

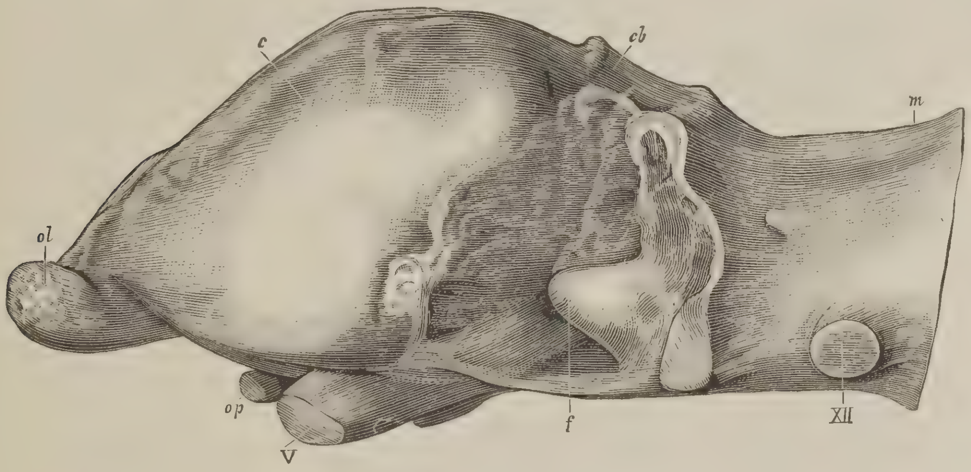


Fig. 60.

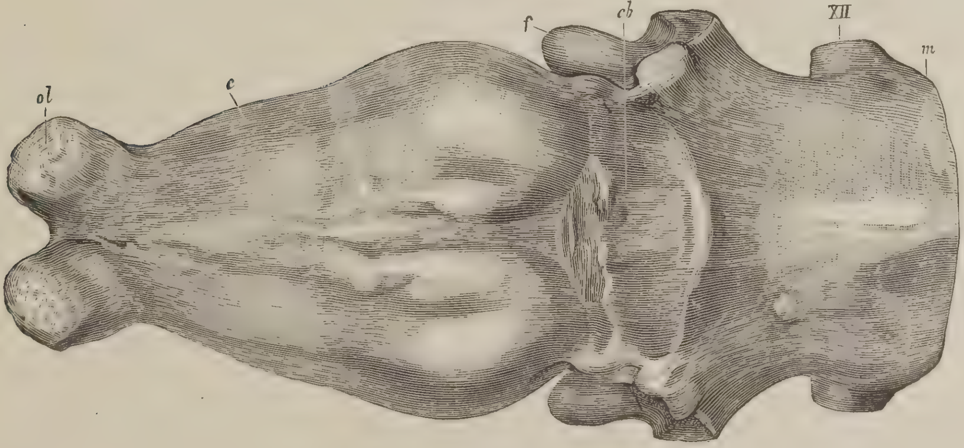


Figure 59.—Cast of brain-cavity of *Tinoceras ingens*, Marsh (No. 1041); side view.
Figure 60.—The same; superior view.

c. cerebral hemispheres; *cb.* cerebellum; *f.* flocculus; *m.* medulla; *ol.* olfactory lobes; *op.* optic nerves; V. fifth nerve; XII. twelfth nerve.

Both figures are three-fourths natural size.

The cribriform plate, bounding these lobes in front, is thin and easily displaced, but its position in the specimen is shown approximately by the extremity of the olfactory lobes represented in Plate VI. In front of this plate the olfactory nerves were spread out in a large cavity, which is represented in figures 30 and 31, page 29. The nasal canals extend forward from this cavity to the external nares, as indicated in the same figures. In these canals there were thin, well developed, ethmo-turbinal bones, which were easily displaced, and broken up. The presence of these bones is strong evidence that there was no proboscis.

The optic nerves, or second pair, were well developed. Their position, size, and place of exit, are shown in Plate VI, figure 3, *op*.

The fifth pair of nerves, or tri-geminals, were very large, and were given off on either side, behind the optics, and opposite the depression for the pituitary body, as shown in Plate VI, figure 3, *v*.

The sixth pair of nerves passed off immediately behind and below the last pair. Their position and relative size are shown in Plate VI, figure 3, *f*. The twelfth pair, or hypoglossal nerves, passing off through the condylar foramina, were large, and their position is given in Plate VI, figure 3, XII, and *cf*. The position and exit of the other nerves sent off from the brain cannot be determined with certainty.

In the genus *Tinoceras*, the brain was similar in its general characters to that of *Dinoceras*, but appears to have been somewhat more highly developed, as shown in figures 59 and 60, page 55. The hemispheres were more elongate, and the olfactory lobes relatively smaller. The cavities for the flocculi were quite large, and directed well forward. The twelfth pair of nerves were largely developed.

In *Uintatherium*, the brain of the type specimen was nearly, or quite, as small as in *Dinoceras*. The hemispheres were short, and moderately expanded transversely. The olfactory lobes were separated by a wide septum, and were much more divergent than in *Dinoceras* or *Tinoceras*. These characters are shown in figures 61 and 62, page 57, which are of the same relative size as the figures in Plate VI.

FIG. 61.

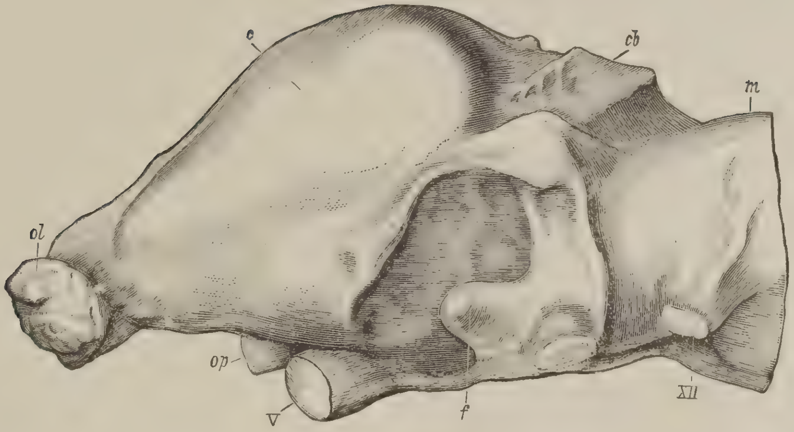


FIG. 62.

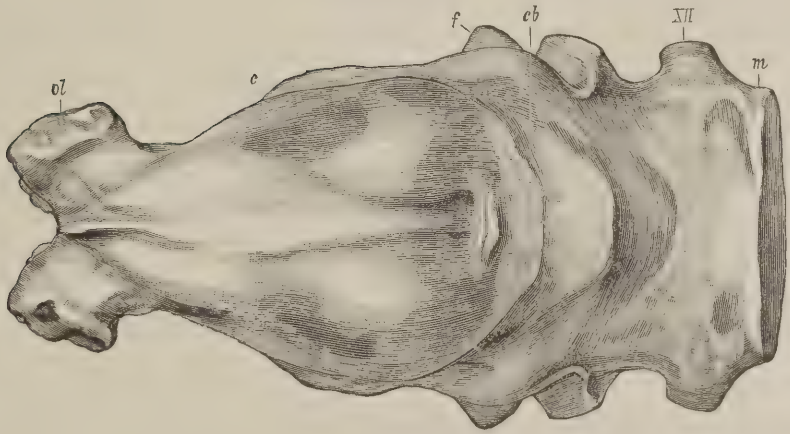


FIGURE 61.—Cast of brain-cavity of *Uintatherium robustum*, Leidy; type specimen, lateral view.
FIGURE 62.—The same; superior view.

c. cerebral hemispheres; *cb.* cerebellum; *f.* flocculus; *m.* medulla; *ol.* olfactory lobes; *op.* optic nerves; V. fifth nerve; XII. twelfth nerve.

Both figures are three-fourths natural size.

BRAIN GROWTH.

The *Dinocerata* are, by far, the largest of all known Eocene land animals, and that they have, also, a very diminutive brain is a noteworthy fact, which attracted the author's attention soon after their discovery.

The comparison of the brain in this group with that of other mammals from the same formation soon showed that the *Dinocerata*, although most remarkable in this respect, were not alone in diminutive capacity of brain power. A more extended comparison led to the fact that all of the early Tertiary mammals had very small brains, and in many of them the brain was of a low, almost reptilian, type. As the comparison was extended to include the mammals from the higher divisions of the Eocene, and from the Miocene, the same fact became more apparent, but a gradual increase in size and quality of the brain soon became evident in extending the investigation to the animals of more recent geological age. In bringing into the investigation the mammals from the Pliocene and Quaternary, the improvement in brain power became still more apparent, and the outline of a general law of brain growth was soon determined.

In tracing thus the different groups of mammals, each from the early Tertiary to the present time, it was found that in every series where the material was sufficient to make a fair comparison, the brain-growth had been constant, and followed the same law.

The results of this investigation were embodied by the author in a general law of brain-growth in the extinct mammals throughout Tertiary time. This law, briefly stated, was as follows:

1. All Tertiary mammals had small brains.

2. There was a gradual increase in the size of the brain during this period.

3. This increase was confined mainly to the cerebral hemispheres, or higher portion of the brain.

4. In some groups, the convolutions of the brain have gradually become more complex.

5. In some, the cerebellum and the olfactory lobes have even diminished in size.

6. There is some evidence that the same general law of brain growth holds good for Birds and Reptiles from the Cretaceous to the present time.[1]

[1] *American Journal of Science and Arts*, Vol. VIII, p. 66, July, 1874; and Vol. XII, p. 61, July, 1876; see also the author's Monograph on the ODONTORNITHES, p. 10, 4to, Washington, 1880.

The author has since continued this line of investigation, and has ascertained that the same general law of brain growth is true for Birds and Reptiles from the Jurassic to the present time.

To this general law of brain growth two additions may now be made, which briefly stated are as follows:

(1.) The brain of a mammal belonging to a vigorous race, fitted for a long survival, is larger than the average brain, of that period, in the same group.

(2.) The brain of a mammal of a declining race is smaller than the average of its cotemporaries of the same group.

An example of the first of these statements is seen in figure 70, page 64, representing the genus *Colonoceras*, one of the Eocene ancestors of the Rhinoceros. The second case is illustrated by figure 82, page 67, of the Hippopotamus, evidently one of the last members of a long line. A study of a larger number of extinct and recent specimens will make these conclusions more apparent.

The results of this study of the whole subject of brain growth, the author intends to bring together in a separate memoir. Some of the principal facts, however, may be appropriately presented in the present volume in connection with the brain characters of the *Dinocerata*, which naturally form the beginning of one series in the investigation.

In any comparison of the size of the brain in different animals, whether in the same group or in others widely different, it is important to bear in mind that:

1. The brain of small animals is proportionally larger in bulk than that of large animals.

2. The brain of young animals is proportionally larger than in those fully adult.

In a general comparison of brain growth of mammals, the first of these facts can have only a limited effect, which would not change, essentially, the general results. The effects of the second fact may be readily eliminated by confining the comparison to adult animals.

In this comparison, moreover, of the extinct forms with those of more modern time, including recent mammals, it may be taken for granted that the brain-cavity of the extinct forms, as well as of those now living, was entirely filled by the brain; since, with a possible single exception, no mammal is known in which this is not the case.

In comparing the size of the brain in mammals with that of reptiles and fishes, an important point to be borne in mind would be the fact, that in the two latter classes the brain-cavity is not always entirely filled by the brain. The present comparison deals with mammals alone, and this restriction is here of no importance.

The fact that among existing mammals there are some anomalous features in the size of the brain in allied groups has not been forgotten, but such instances, even if they occurred among extinct mammals, would not materially affect the general comparison here proposed.

In the following pages a series of figures is given, showing the comparative size of the brain, and its position in the skull in a number of the larger ungulate mammals, recent and extinct. To make the comparison a fair one, the skulls are all drawn of the same absolute size, thus showing, at once, the relative proportion of the brain in each. The skulls are placed horizontally, the plane of the molar teeth being as a rule taken as a base. In the case of the four artiodactyls, figures 80 to 83, page 67, this position has been somewhat changed, as, in this group of ungulates, the brain is more or less inclined backward in the skull. In these cases, the skull is represented as somewhat inclined forward, thus raising the posterior part of the brain. The angle of inclination of the face and of the brain, is made equal, thus giving to both the best position for comparison, and not materially affecting it for the present purpose.

A striking illustration of the development of the brain from the early Tertiary to the present time may be seen in figures 63–65, page 61, where is shown, first, the skull of *Dinoceras*, the largest land mammal of the Eocene, with the brain in position; second, the skull of the gigantic Miocene *Brontotherium*, with the brain also in position; and third, the skull of the recent horse. Other comparisons, equally striking, can readily be made.

FIG. 63.

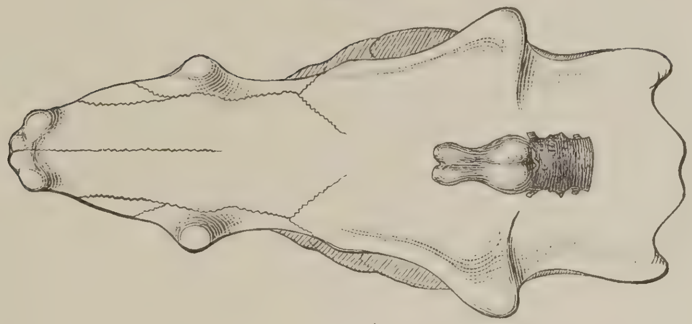


FIG. 64.

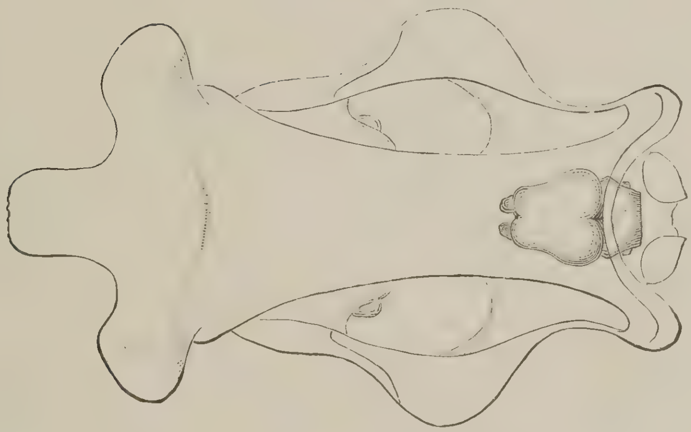


FIG. 65.

FIGURE 63.—Outline of skull of *Dinoceras mirabile*, Marsh; with cast of brain-cavity in position: about one-eighth natural size. Eocene.

FIGURE 64.—Outline of skull of *Brontotherium ingens*, Marsh; with cast of brain-cavity in position; one-tenth natural size. Miocene.

FIGURE 65.—Outline of skull of horse, *Equus caballus*, Linnæus; with cast of brain-cavity in position; about one-sixth natural size. Recent.

The small size of the brain in early Tertiary mammals will be indicated by an examination of the *Dinocerata* skulls, with the brain in position, shown in figures 57 and 58, page 54. This is further shown by figure 66, page 63, which represents the skull and brain of *Coryphodon*, the largest mammal in the lower Eocene, from beds of earlier age than those containing the *Dinocerata*, as shown in the section, figure 2, page 7.

The size of the brain in the middle Eocene genera *Palæosyops*, *Lymnohyus*, *Colonoceras*, and *Hyrachyus* are shown in figures 68 to 71, pages 63 and 64. *Amynodon* from the upper Eocene is represented in figure 72, page 64.

The larger brain of the Miocene mammals is indicated by the figure 64, page 61, representing the skull of *Brontotherium*, which is found at the base of the Miocene, as shown in figure 2, page 7. *Elotherium* from the same horizon is represented in figure 75. The skull of *Eporeodon*, with its brain in position, figure 73, page 64, also affords a good illustration of a mammal from this formation. This genus is found in the middle Miocene, as shown in the section, page 7.

The still more developed brain of the Pliocene mammals is seen in figure 74, page 65, which gives a view of the skull of the Mastodon, with the brain in position. In figure 76, page 65, the skull and brain of an extinct Pliocene peccary further illustrates the same law of brain-growth.

On comparing these various figures with those representing the brains and skulls of the existing Ungulates, as shown by the succession in figures 77–83, on pages 66–67, the reader will have before him a series of facts which illustrate the laws of brain-growth given on page 58. The comparison, here confined to the representative ungulate mammals, might easily be extended much farther, but would not come within the scope of the present volume.

The author has made similar comparisons in other groups of mammals, including those that can be followed from the early Tertiary to the present time, and the results are uniformly the same. These results the author hopes to present fully elsewhere at no distant day.

FIG. 66.

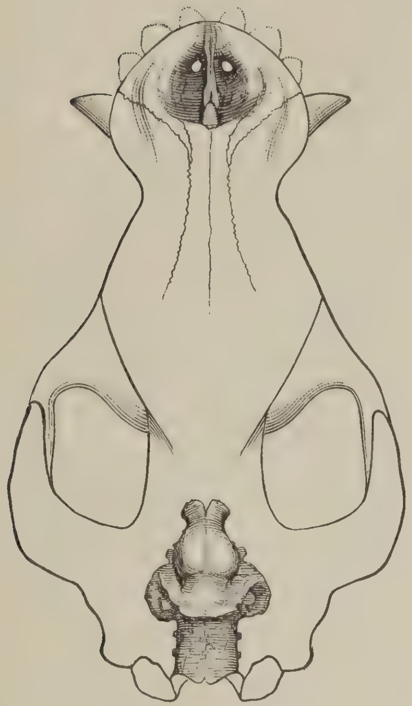


FIG. 67.

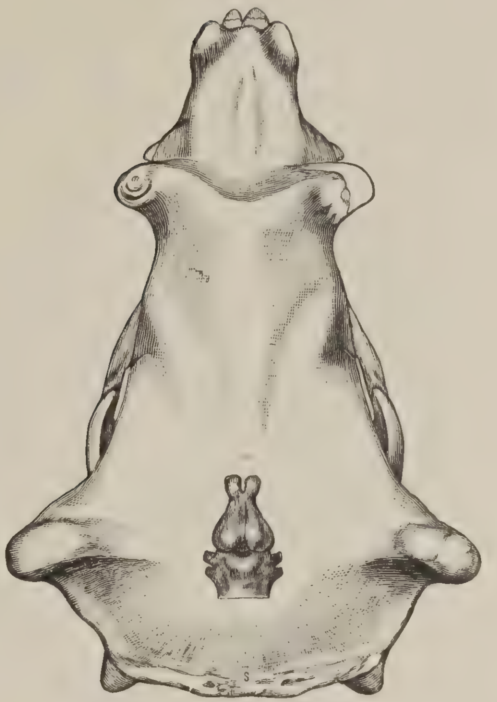


FIG. 68.

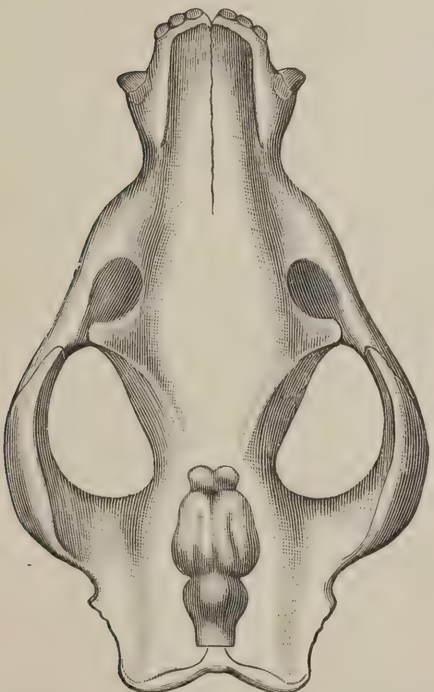


FIG. 69.

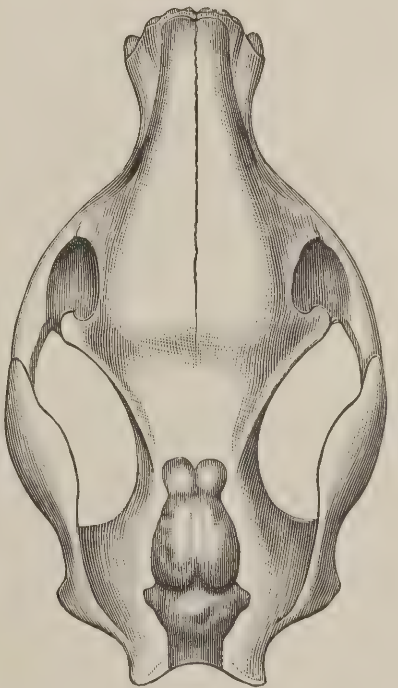


FIGURE 66.—*Coryphodon hamatus*, Marsh. Eocene.

FIGURE 67.—*Tinoceras pugnax*, Marsh. Eocene.

FIGURE 68.—*Palæosyops laticeps*, Marsh. Eocene.

FIGURE 69.—*Limnohyus robustus*, Marsh. Eocene.

FIG. 70.

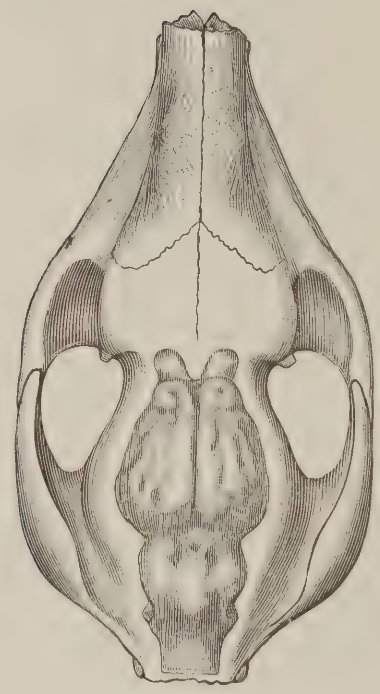


FIG. 71.

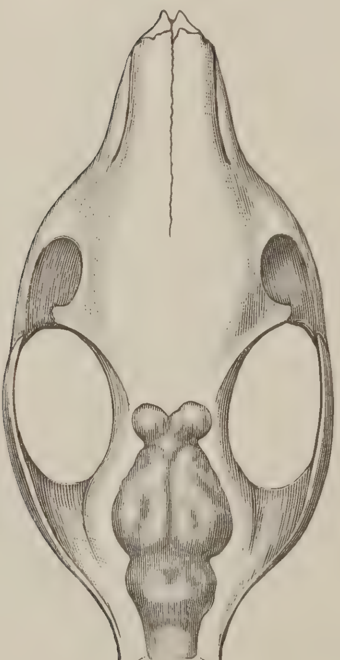


FIG. 72.

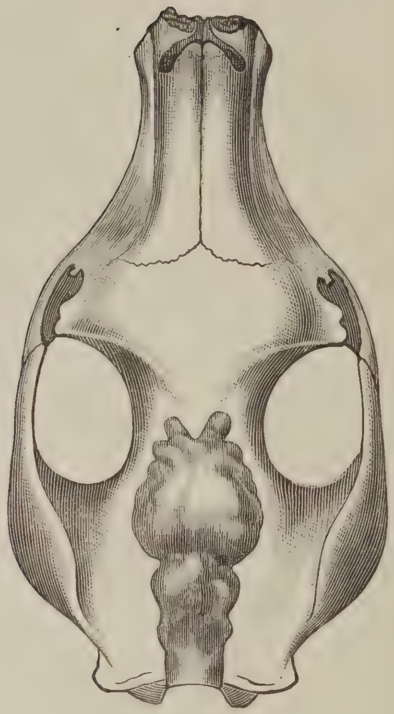


FIG. 73.

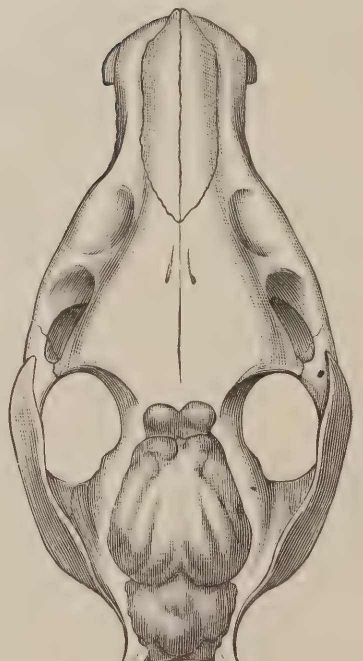


FIGURE 70.—*Colonoceras agrestis*, Marsh. Eocene.
FIGURE 71.—*Hyrachyus Bairdianus*, Marsh. Eocene.

FIGURE 72.—*Amynodon advenus*, Marsh. Eocene.
FIGURE 73.—*Eporeodon socialis*, Marsh. Miocene.

FIG. 74.

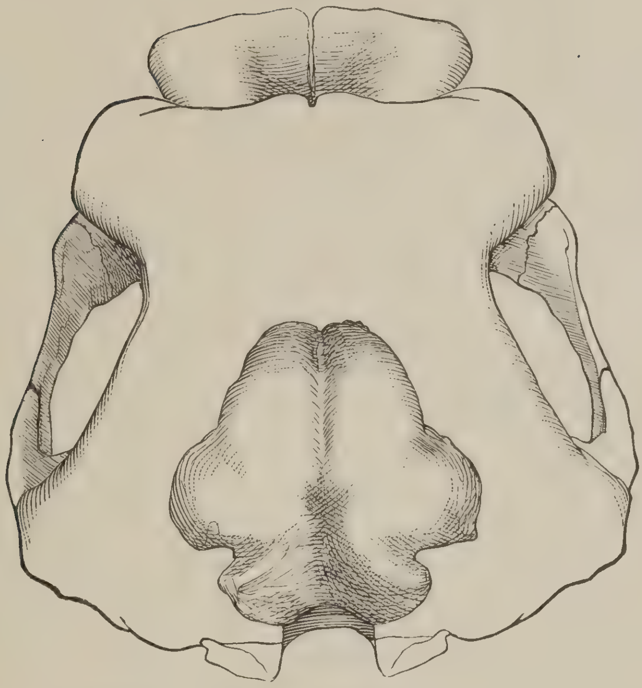


FIGURE 74.—*Mastodon Americanus*, Cuvier. Pliocene.

FIG. 75.

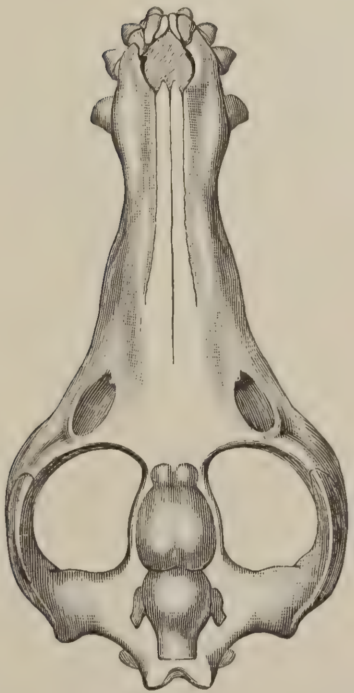


FIGURE 75.—*Elotherium crassum*, Marsh. Miocene.

FIG. 76.

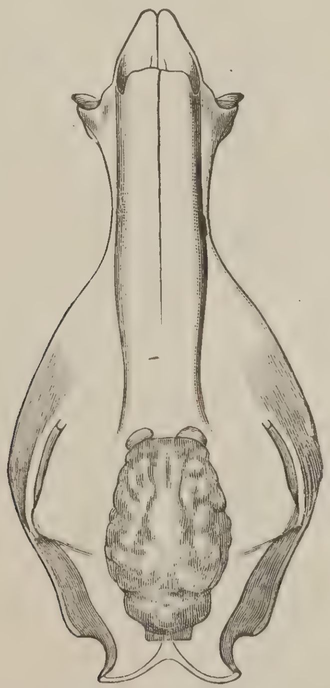


FIGURE 76.—*Platygonus compressus*, LeConte. Pliocene.

Fig. 77.

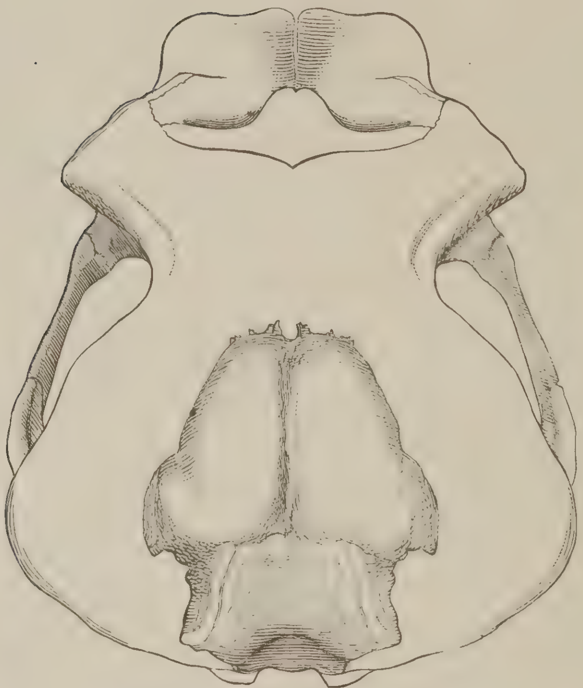


Figure 77.—*Elephas Indicus*, Linnæus.

Fig. 78.

Figure 78.—*Tapirus terrestris*, Linnæus.

Fig. 79.

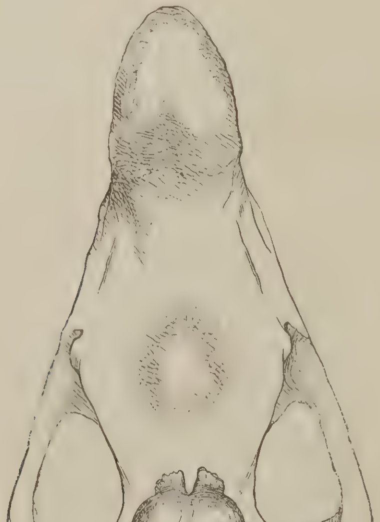


Figure 79.—*Rhinoceros Sumatrensis*, Cuvier.

Fig. 80.

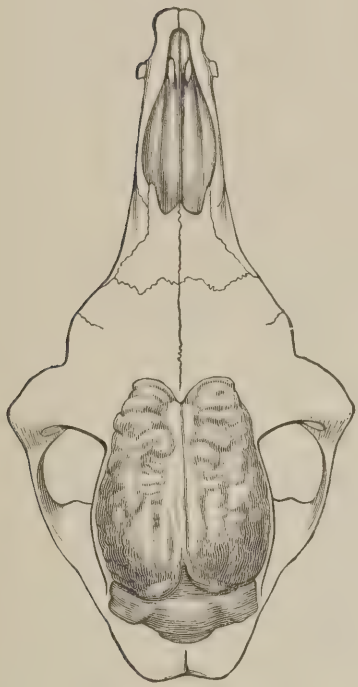


Fig. 81.

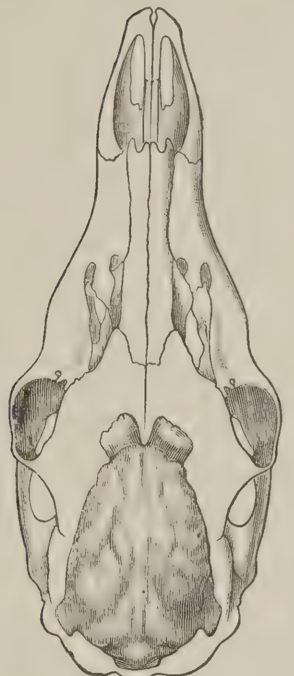


Fig. 82.

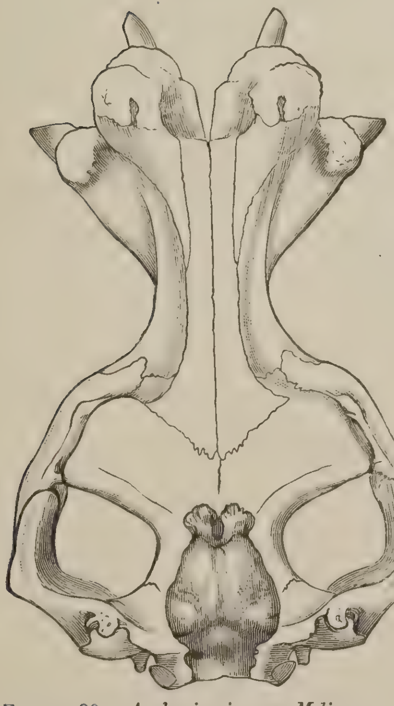


Fig. 83.

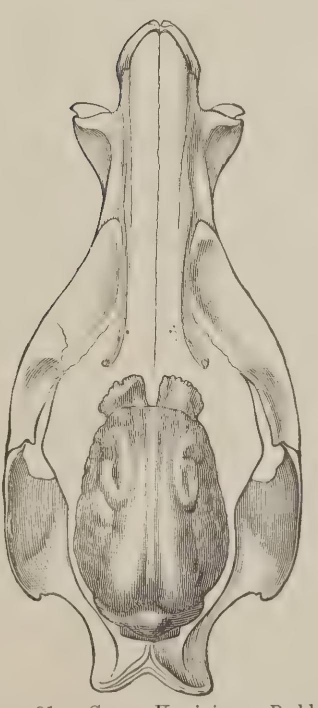


Figure 80.—*Auchenia vicugna, Molina.*
Figure 82.—*Hippopotamus amphibius*, Linnæus.

Figure 81.—*Cervus Virginianus*, Boddaut.
Figure 83.—*Dicotyles torquatus*, Cuvier.

CHAPTER V.

THE CERVICAL VERTEBRÆ.

(Plates XX, XXI, XXII, LV, and LVI.)

The cervical vertebræ of the *Dinocerata*, in their main characters, resemble those of the Proboscidians. The atlas and axis are somewhat similar to those of the elephant. The rest of the cervicals are proportionally longer. The entire neck was about one-third longer than in the elephant, thus rendering a proboscis unnecessary, as the head could readily reach the ground.

All the presacral vertebræ, behind the atlas and axis, have the articular faces of the centra nearly flat, as in the typical Proboscidians. In other respects, they present no strongly marked characters of importance.

The Atlas.

(Plate XX; and woodcuts 84, 85, and 86, below.)

The atlas in the *Dinocerata* is a massive bone, presenting the ordinary articular faces of this vertebra. The anterior pair of these, for the reception of the occipital condyles, are well separated above and below. The three posterior faces, for articulation with the second vertebra, or axis, are also widely separated from each other. All these three faces are sub-circular in outline, and the lateral ones are somewhat emarginate

along the inner side. The median facet, for articulation with the odontoid process, is flattened in front, or slightly convex in antero-posterior direction, and extends longitudinally over the greater part of the inferior arch of the atlas. Its boundaries are well marked on all sides, as are also those of the lateral faces. Hence the articulation between the atlas and axis admitted but little rotary motion to the head.

The spine of the atlas is not well marked, although the superior arch is massive, and its anterior surface is rough and tuberculated. This arch is pierced on each side anteriorly by a foramen (figure 84, *d*), the inner opening of which is just above the inner and upper angle of the condylar articular surface. Externally, this foramen is connected by a more or less evident groove with one piercing the transverse process lengthwise. This groove runs vertically down the side of the atlas, and through a deep notch in the anterior margin of the transverse process. In the tapir, this groove passes through a foramen, instead of a notch in the anterior part of the transverse process. A similar arrangement is seen in the horse, ox, sheep, camel, and in various other Ungulates.

The transverse processes of the atlas are short, and strong. They are moderately flattened, thicker and stouter behind than before, and placed obliquely, so as to slant strongly downward and backward. Anteriorly, the outer margin runs rapidly down to the lateral arch of the atlas, but is separated from it at the base of the process by the deep notch, mentioned above. Posteriorly, they are thickened and rugose. The base of each lateral process is perforated by a foramen, directed somewhat downward, and forward. The under surface of the atlas (figure 86) is smooth and even, with no rugosity to mark the median line.

The atlas of *Dinoceras mirabile* is shown in Plate XX, and that of *Tinoceras grande*, in the woodcuts below, figures 84, 85, and 86. The position of the atlas, with reference to the skull, is represented in the restorations in Plates LV and LVI.

FIG. 84.

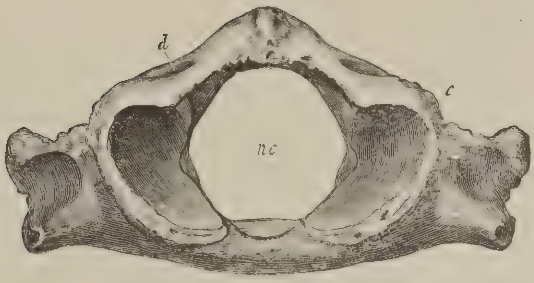


FIG. 85

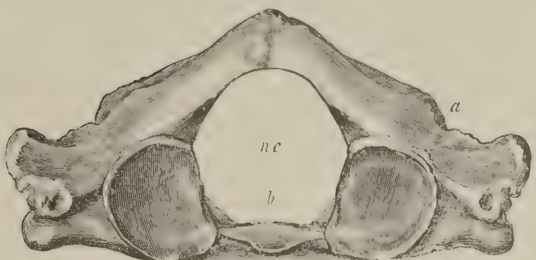


FIG. 86.

FIGURE 84.—Atlas of *Tinoceras grande*, Marsh (No. 1040); front view.
FIGURE 85.—The same vertebra; back view.
FIGURE 86.—The same vertebra; bottom view.
a. face for axis; *b.* face for odontoid process of axis; *c.* face for occipital condyle of skull; *d.* foramen in neural arch for spinal nerve; *nc.* neural canal.
All the figures are one-fourth natural size.

The following measurements give the principal dimensions of the atlas in one specimen of *Dinoceras:*

Measurements of Atlas. (*Dinoceras mirable*, No. 1251.)

	m.
Greatest transverse diameter of atlas,	.265
Greatest vertical diameter of atlas,	.142
Transverse diameter of neural canal,	.090
Vertical diameter of neural canal,	.080
Antero-posterior diameter of superior arch,	.067
Vertical diameter of superior arch,	.034
Antero-posterior diameter of inferior arch,	.149
Diameters of faces for occipital condyles,	.072–.052
Distance between faces for occipital condyles, above,	.080
Distance between faces for occipital condyles, below,	.058
Diameters of face for odontoid process,	.043–.035
Diameters of lateral faces for axis,	.063–.056
Distance between lateral faces for axis,	.065

The Axis. (Plate XXI.)

The axis in *Dinoceras mirabile* (number 1036) is robust, and proportionally shorter than the corresponding vertebra in the tapir. The centrum is moderately flattened below, but not excavated as in the tapir, and presents, medially, a tuberculation at the union of its centrum with that of the first vertebra. The odontoid process is distinctly conical, and not at all excavated above. Its perpendicular diameter, moreover, exceeds its transverse. It is pointed in front, and bears, on its under surface, a saddle-shaped articular face for union with the atlas. This surface is not confluent with the lateral surfaces, as in the elephant, tapir, and most Ungulates, but is perfectly distinct, as in the kangaroo, and in man. The lateral articular faces are moderately convex in both directions, and have their longest diameter nearly transverse.

The neural arch is massive, and its lateral walls are not pierced by foramina, agreeing, in that respect, with those of the kangaroo. On the lateral surfaces of the centrum, the vertebrarterial, or lateral, foramen was present, and circumscribed by bone. Its upper wall was much weaker than the lower, instead of subequal, as in the tapir. The neural arch is surmounted by a short and stout neural spine, low in front, and rising behind, though less rapidly than in the tapir, and becoming rather indistinctly bifid at the top. The neural spine is deeply excavated behind.

The posterior zygapophyses are robust, slightly convex, and look more downward than outward, and only slightly backward. The posterior face of the centrum is transverse, and broadly oval in outline. The floor of the neural canal is flattened, and presents a number of vascular foramina leading into the centrum.

The transverse processes of this specimen are imperfectly preserved, but were evidently pierced, above the middle, by a large lateral foramen. The processes appear to have been directed rather less strongly backward than in the tapir.

The principal dimensions of the axis in three specimens of *Dinoceras* are as follows:

Measurements of Axis. (*Dinoceras mirabile*, No. 1036.)

	m.
Length of axis, on floor of neural canal (approximate),	.150
Length of odontoid process,	.056
Transverse diameter of odontoid process,	.035
Vertical diameter of odontoid process,	.052
Transverse diameter of anterior articular face,	.068
Vertical diameter of anterior articular face,	.065
Transverse diameter of vertebra, across anterior articular faces,	.148
Transverse diameter of neural canal,	.053
Vertical diameter of neural canal,	.042
Transverse diameter of vertebra, across post-zygapophyses,	.122
Transverse diameter of posterior face of centrum,	.093
Vertical diameter of posterior face of centrum,	.072
Height of axis, to top of neural spine,	.175
Transverse diameter of neural spine,	.048
Antero-posterior diameter of neural spine,	.085

Measurements of Axis. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of axis, on floor of neural canal (approximate),	.125
Length of centrum, along under surface,	.140
Length of odontoid process, from lateral articular faces,	.045
Transverse diameter of odontoid process,	.037
Vertical diameter of odontoid process,	.038
Transverse diameter of articular face of odontoid process,	.035
Antero-posterior diameter of articular face of odontoid process,	.042
Transverse diameter of neural canal,	.039
Vertical diameter of lateral foramen,	.012

Measurements of Axis. (*Dinoceras lucare*, No. 1038.)

	m.
Total length of axis,	.170
Length, from end of odontoid process to end of neural canal,	.148
Transverse diameter of odontoid process,	.035
Vertical diameter of odontoid process,	.046
Greatest diameter of anterior articular face,	.070
Transverse diameter, across anterior articular faces,	.142
Antero-posterior diameter of face on odontoid process,	.044
Transverse diameter of face on odontoid process,	.033
Distance between antero-lateral articular faces,	.050
Transverse diameter of centrum, behind faces,	.125
Transverse diameter, across post-zygapophyses,	.115
Transverse diameter of posterior face of centrum,	.093
Vertical diameter of posterior face of centrum,	.080
Diameters of lateral foramen,	.013–.020
Diameters of neural canal (approximate),	.040–.050

The Third Vertebra. (Plate XXII, figures 1–5.)

The third cervical of *Dinoceras mirabile* (number 1036) is shown in Plate XXII, figures 1–5. This vertebra, in the type specimen, is not in a good state of preservation, but represents fairly the main characters of the third cervical in this genus.

The pre-zygapophyses are somewhat concave, to fit the convex post-zygapophyses of the axis. The neural canal is large, and the arch above it is only moderately developed, and without a spine. The lateral, or vertebrarterial, foramen is oval in outline, and is protected by a strong transverse process. The under surface of the centrum is marked by a median longitudinal keel, as shown in figures 3 and 5.

The third cervical vertebra of *Dinoceras mirabile* (number 1255) is short, and the articular faces of the centrum are both somewhat concave. The anterior face is slightly less excavated than the posterior. The length of the centrum is less than its vertical diameter, and the latter is greater than the transverse diameter. The epiphyses are incompletely ossified, and only imperfectly united to the centrum. These general characters apply also to the remaining cervical vertebræ.

The principal dimensions of the third vertebra in one specimen of *Dinoceras* are as follows:

Measurements of Third Cervical Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of floor of neural canal (approximate),	.055
Length of centrum, along under surface,	.058
Vertical diameter of posterior epiphysis,	.078
Antero-posterior extent of zygapophyses,	.092
Diameter of lateral foramen (approximate),	.020

The Fourth Vertebra. (Woodcuts 87 and 88, below.)

The fourth cervical vertebra in *Dinoceras* resembles, in its main characters, the one last described. The pre-zygapophyses are nearly flat. The neural canal is somewhat smaller. The process to protect the lateral foramen is more strongly developed, and the under surface of the centrum is without a distinctly marked keel.

The fourth vertebra in *Tinoceras grande* is similar, in its more important characters, although proportionally shorter, and its principal features are well shown in figures 87 and 88, below.

FIG. 87.

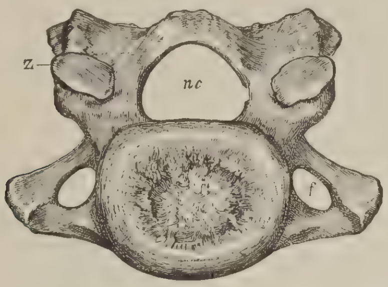


FIG. 88.

FIGURE 87.—Fourth cervical vertebra of *Tinoceras grande*, Marsh (No. 1040); front view.
FIGURE 88.—The same vertebra; side view.
f. lateral foramen; *nc.* neural canal; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.
Both figures are one-fourth natural size.

The main dimensions of the fourth vertebra in one species each of *Dinoceras* and *Tinoceras* are given below.

Measurements of Fourth Cervical Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of floor of neural canal,	.055
Length of centrum, along under surface,	.054
Transverse diameter of anterior epiphysis,	.079
Vertical diameter of anterior epiphysis,	.075
Transverse diameter of posterior epiphysis,	.091
Vertical diameter of posterior epiphysis,	.075
Antero-posterior extent of zygapophyses,	.089
Diameter of lateral foramen,	.024
Transverse diameter of neural canal,	.043

Measurements of Fourth Cervical Vertebra. (*Tinoceras grande*, No. 1040.)

	m.
Length of floor of neural canal,	.042
Length of centrum, on under surface of vertebra,	.045
Transverse diameter of anterior face,	.100
Vertical diameter of anterior face,	.094
Transverse diameter of neural canal,	.055
Vertical diameter of neural canal,	.040
Diameters of lateral foramen,	.025–.015

THE FIFTH VERTEBRA. (Woodcuts 89 and 90, below.)

In the fifth cervical vertebra of *Dinoceras mirabile* (number 1255), the centrum is nearly round. The articular faces are distinctly concave, especially the posterior one. The neural canal is sub-triangular in transverse section. The arch to protect the lateral foramen is more depressed than in the preceding vertebra. The more important features of this vertebra are shown in figure 89, below.

FIG. 89.

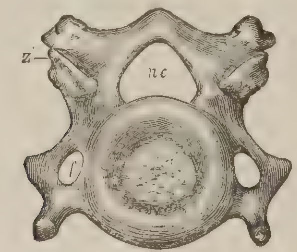


FIG. 90.

FIGURE 89.—Fifth cervical vertebra of *Dinoceras mirabile*, Marsh (No. 1255); front view.
FIGURE 90.—The same vertebra; side view.
f. lateral foramen; *nc.* neural canal; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.
Both figures are one-fourth natural size.

The principal measurements of the fifth vertebra in this specimen of *Dinoceras mirabile* are the following:

Measurements of Fifth Cervical Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of floor of neural canal,	.052
Length of centrum, along under surface,	.055
Transverse diameter of neural canal,	.046
Vertical diameter of neural canal,	.035
Transverse diameter of anterior epiphysis,	.079
Vertical diameter of anterior epiphysis,	.074
Transverse diameter of posterior epiphysis,	.089
Vertical diameter of posterior epiphysis,	.080
Antero-posterior extent of zygapophyses,	.083
Transverse diameter, across pre-zygapophyses,	.120
Transverse diameter, across post-zygapophyses,	.123
Diameter of lateral foramen (approximate),	.020

THE SIXTH VERTEBRA. (Woodcuts 91–94, below.)

The sixth cervical vertebra of *Dinoceras mirabile* (number 1255) has the articular faces of the centrum more transverse than in the preceding vertebra. The neural canal is sub-cordate in outline, and the transverse processes, to protect the lateral foramen, are more strongly developed than in the vertebra last described.

FIG. 91.

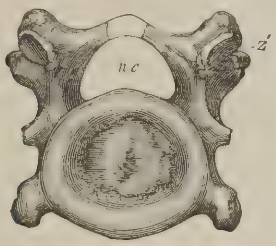


FIG. 92.

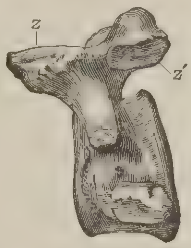


FIGURE 91.—Sixth cervical vertebra of *Dinoceras mirabile*, Marsh (No. 1255); back view.
FIGURE 92.—The same vertebra; side view.
nc. neural canal; *z*. anterior zygapophysis; *z'*. posterior zygapophysis.
Both figures are one-fourth natural size.

FIG. 93.

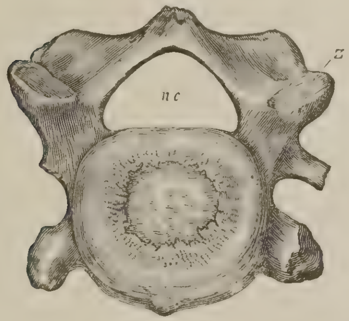


FIG. 94.

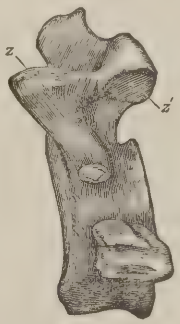


FIGURE 93.—Sixth cervical vertebra of *Dinoceras cuneum*, Marsh (No. 1042); front view.
FIGURE 94.—The same vertebra; side view.
nc. neural canal; *z*. anterior zygapophysis; *z'*. posterior zygapophysis.
Both figures are one-fourth natural size.

In the sixth vertebra of *Dinoceras cuneum*, there is a distinct neural spine, and the centrum is slightly quadrate in outline, as shown in figure 93. The latter is shorter than in the corresponding vertebra of *Dinoceras mirabile*, as seen by a comparison of figures 92 and 94.

Measurements of the sixth cervical vertebra in two individuals of *Dinoceras* are as follows:

Measurements of Sixth Cervical Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of floor of neural canal,	.049
Length of centrum, along under surface,	.055
Transverse diameter of neural canal,	.051
Vertical diameter of anterior epiphysis,	.076
Transverse diameter of posterior epiphysis,	.088
Vertical diameter of posterior epiphysis,	.078
Antero-posterior extent of zygapophyses,	.087

Measurements of Sixth Cervical Vertebra. (*Dinoceras cuneum*, No. 1042.)

	m.
Transverse diameter of centrum,	.111
Length of centrum, along under surface,	.053
Transverse diameter of neural canal,	.071
Vertical diameter of neural canal (approximate),	.044
Transverse diameter of anterior face of centrum,	.100
Vertical diameter of anterior face of centrum,	.092
Diameter of vertebra, across pre-zygapophyses (approximate),	.170
Diameters of lateral foramen,	.022–.034
Antero-posterior diameter of pedicel,	.026

The Seventh Vertebra. (Plate XXII, figures 6–10.)

The seventh cervical vertebra of *Dinoceras mirabile* (number 1255) has the anterior face of the centrum nearly circular. The posterior face is expanded transversely, and its lateral margins are cut by the facets for the head of the first rib. The neural canal is distinctly sub-cordate in outline, and there is a rudimentary neural spine. The lateral foramen has disappeared, but the transverse process is notched below for the passage of the vertebral artery. These characters are shown in Plate XXII, figures 8 and 10.

Measurements of Seventh Cervical Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of floor of neural canal,	.046
Length of centrum, along under surface,	.051
Transverse diameter of neural canal,	.061
Vertical diameter of neural canal (approximate),	.046
Transverse diameter of anterior articular face (approximate),	.076
Transverse diameter of posterior articular face (approximate),	.075
Antero-posterior extent of zygapophyses,	.084
Diameters of articulation for first rib,	.022–.035
Diameter, across transverse processes (approximate),	.185

CHAPTER VI.

THE DORSO-LUMBAR VERTEBRÆ.

(Plates XXIII, XXIV, XXV, XXVI, LV and LVI.)

The trunk vertebræ in the *Dinocerata* are proportionally longer than those in the cervical region. The articular faces of the centra are likewise nearly flat, the most of them being distinctly concave. The epiphyses are usually loosely united to the centra, and thin, or imperfectly ossified, near the center. The number of trunk vertebræ in *Dinoceras* was apparently twenty-three.

The First Dorsal Vertebra. (Woodcuts 95–98, below.)

The first dorsal vertebra in *Dinoceras mirabile* (number 1255) has a slender, but elevated, neural spine, as shown in figure 95, below. It is distinguished from the adjoining elements of the column by the presence of elevated and oblique pre-zygapophyses, for articulation with the last cervical. These processes are much farther apart than the post-zygapophyses, and look obliquely upward, inward, and slightly backward, while the latter look almost directly downward. The pedicels of this vertebra stand mostly on the anterior half of the centrum. They are about twice as great in transverse as in antero-posterior diameter, and are directed well outward. The laminæ form a much greater proportion of the neural arch than in the tapir, and are depressed at the middle, giving a somewhat triangular outline to the large neural canal. The epiphyses in this specimen are unossified for more than half their diameter, and imperfectly united to the centrum.

The transverse processes are short, and strongly tuberculated at the end. The articular surfaces for the heads of the first and second ribs are of about equal size, and sub-oval in outline. They are approximate at the sides of the centrum, being separated from each other by less than half their diameter. The face for the tubercular articulation of the first rib is of moderate size, oval in outline, concave from before backward, and much less so transversely. These articulations are about on a level with the floor of the neural canal, instead of below it, as in the tapir.

FIG. 95.

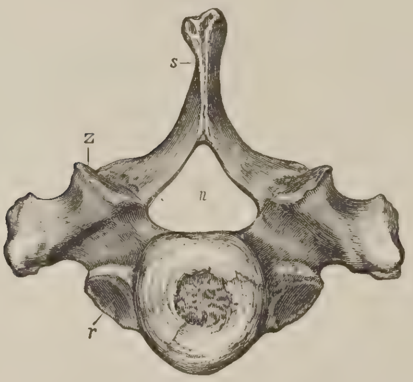


FIG. 96.

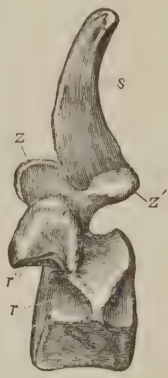


FIGURE 95.—First dorsal vertebra of *Dinoceras mirabile*, Marsh (No. 1212); front view.
FIGURE 96.—The same vertebra; side view.
n. neural canal; *r.* face for head of rib; *r'.* face for tubercle of rib; *s.* neural spine; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.
Both figures are one-fourth natural size.

FIG. 97.

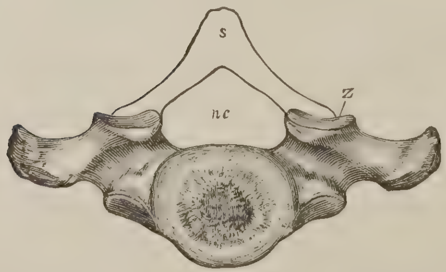


FIG. 98.

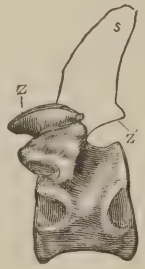


FIGURE 97.—First dorsal vertebra of *Tinoceras anceps*, Marsh (No. 1030); front view.
FIGURE 98.—The same vertebra; side view.
nc. neural canal; *z.* anterior zygapophysis; *z'.* posterior zygapophysis; *s.* neural spine.
Both figures are one-fourth natural size.

The first dorsal in the type specimen of *Tinoceras anceps* (number 1030) is shown in figures 97 and 98, on page 80. In other specimens of *Tinoceras*, this vertebra presents the same general characters.

The principal dimensions of a first dorsal vertebra of *Dinoceras*, and of this vertebra in the type specimen of *Tinoceras*, are given below.

Measurements of First Dorsal Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of centrum, along floor of neural canal,	.048
Length of centrum, along inferior surface,	.058
Vertical diameter of anterior face of centrum,	.072
Transverse diameter of anterior face of centrum,	.075
Vertical diameter of posterior face of centrum,	.073
Transverse diameter of posterior face of centrum,	.073
Vertical diameter of neural canal,	.046
Transverse diameter of neural canal,	.065
Greatest diameter, across transverse processes,	.210
Diameter of pre-zygapophyses,	.030
Distance across pre-zygapophyses,	.140
Diameter of post-zygapophyses,	.031
Distance across post-zygapophyses,	.115
Diameters of anterior face for head of rib,	.030–.038
Diameters of posterior face for head of rib,	.027–.037
Diameters of face for tubercle of rib,	.025–.032
Transverse diameter of pedicel,	.044
Antero-posterior diameter of pedicel,	.022
Distance between faces for head of rib,	.015

Measurements of First Dorsal Vertebra. (*Tinoceras anceps*, No. 1030.)

	m.
Length of floor of neural canal,	.056
Length of centrum, along under surface,	.056
Transverse diameter of anterior face of centrum,	.070
Vertical diameter of anterior face of centrum (approximate),	.063
Transverse diameter of posterior face of centrum,	.080
Vertical diameter of posterior face of centrum,	.066
Transverse diameter of neural canal,	.068
Vertical diameter of neural canal (approximate),	.037
Diameters of anterior capitular face,	.031–.035
Diameters of posterior capitular face,	.033–.040
Antero-posterior diameter of pedicel,	.030
Transverse diameter of pedicel,	.029
Diameter of vertebra, across transverse processes,	.175

The Second Dorsal Vertebra.

(Plate XXIII; and woodcuts 99–100, below.)

The second dorsal vertebra in *Dinoceras mirabile* (number 1255) is especially distinguished from the one last described by the neural spine, which is massive, and more inclined backward. The neural canal is sub-triangular in outline. The pre-zygapophyses are much smaller, less elevated, and look more directly upward. The centrum is somewhat longer than that of the first dorsal, and more expanded transversely. This vertebra is represented in Plate XXIII.

The second dorsal vertebra of *Dinoceras mirabile* (number 1212) has the neural spine still more massive, the neural canal more expanded transversely, and the articular faces of the centrum more nearly circular, as shown in figures 99 and 100, below.

In the genus *Tinoceras*, the second dorsal presents the same general features as in the vertebra above described.

Fig. 99.

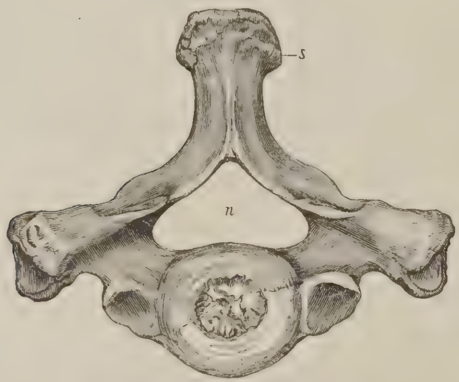


Fig. 100

Figure 99.—Second dorsal vertebra of *Dinoceras mirable*, Marsh (No. 1212); front view.
Figure 100.—The same vertebra; side view.
n. neural canal; *s.* neural spine; *z′.* posterior zygapophysis.
Both figures are one-fourth natural size.

The more important measurements of the second dorsal vertebra of one specimen of *Dinoceras* are as follows:

Measurements of Second Dorsal Vertebra. (*Dinoceras mirabile*, No. 1255.)

	m.
Length of centrum, along floor of neural canal,	.048
Length of centrum, along under surface,	.060
Transverse diameter of anterior face of centrum,	.073
Vertical diameter of anterior face of centrum,	.075
Transverse diameter of posterior face of centrum,	.075
Vertical diameter of posterior face of centrum,	.070
Transverse diameter of neural canal,	.065
Vertical diameter of neural canal,	.057
Diameters of anterior capitular face,	.029-.033
Diameters of posterior capitular face,	.029-.040
Antero-posterior diameter of pedicel,	.025
Transverse diameter of pedicel,	.040
Diameter of vertebra, across transverse processes,	.200
Diameter of vertebra, across post-zygapophyses,	.080
Least transverse diameter of neural spine,	.035

THE THIRD DORSAL VERTEBRA. (Woodcuts 101 and 102, below.)

The third dorsal vertebra in the genera *Dinoceras* and *Tinoceras* differs from the vertebra in front of it, in having the neural spine less robust, and the transverse processes, and the faces for the heads of the ribs on the centrum, more elevated. The centrum itself is less expanded transversely, and its length is greater.

FIG. 101.

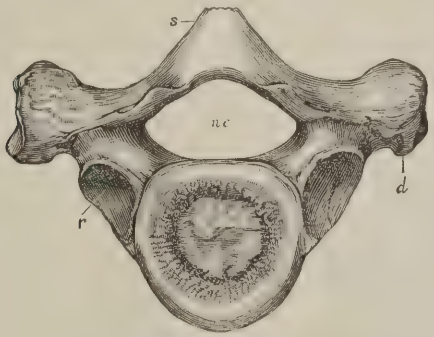


FIG. 102.

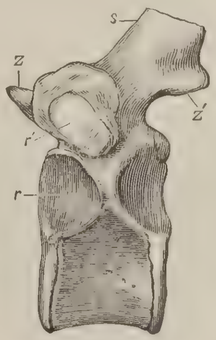


FIGURE 101.—Third dorsal vertebra of *Uintatherium segne*, Marsh (No. 1194); front view.
FIGURE 102.—The same vertebra; side view.

d. transverse process; *nc.* neural canal; *r.* face for head of rib; *r'.* face for tubercle of rib; *s.* neural spine.

Both figures are one-fourth natural size.

The third dorsal in *Uintatherium segne* (number 1194) shows essentially the same characteristics, and is represented in figures 101 and 102, above.

The Median and Posterior Dorsal Vertebræ.

(Plate XXIV; and woodcuts 103–105, below.)

In the dorsal vertebræ of *Dinoceras*, behind the third, the neural spine gradually becomes shorter and weaker, and the neural canal, transversely oval in outline. The transverse processes are more elevated, and shorter. The centrum becomes more compressed below, so that the articular faces are sub-triangular in outline, as shown in Plate XXIV, figure 2.

In the posterior dorsals, the neural spine is quite short, and weak. The anterior zygapophyses have their articular faces recurved, as in the ruminant mammals. The neural canal is a broad oval in transverse outline. The transverse processes are much elevated, and the articular faces for the ribs on these, and on the centrum below, gradually become smaller. The centrum is longer, distinctly keeled below, and its articular faces are triangular in outline, the three sides being nearly equal. These features are shown in figures 103–105.

The last dorsal vertebra of *Dinoceras mirabile* (number 1215) is represented in Plate XXIV, figures 5–9. A posterior dorsal of another species is shown below.

Fig. 103.

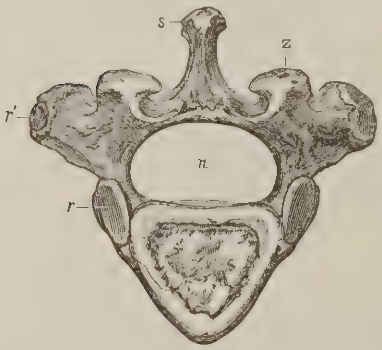


Fig. 104.

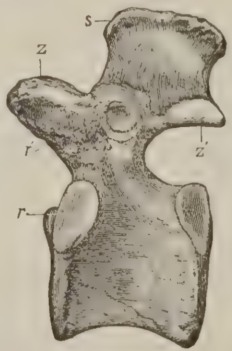


Fig. 105.

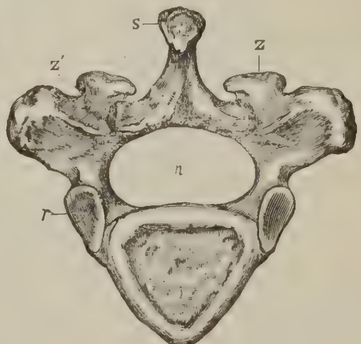


Figure 103.—Posterior dorsal vertebra of *Dinoceras lucare*, Marsh (No. 1038); front view.
Figure 104.—The same vertebra; side view.
Figure 105.—The same vertebra; back view.

n. neural canal; *r.* face for head of rib; *r′.* face for tubercle of rib; *s.* neural spine; *z.* anterior zygapophysis; *z′.* posterior zygapophysis.

All the figures are one-fourth natural size.

The Lumbar Vertebræ.

(Plates XXV and XXVI.)

The last four lumbar vertebræ of the type specimen of *Dinoceras mirabile* (number 1036) are preserved, and are figured in Plates XXV and XXVI. The centra are proportionally much longer than in the mastodon, and the most anterior of the four is excavated at the sides, and keeled below, so as to be nearly triangular in a vertical section near the middle. The excavation becomes less decided in the succeeding vertebræ, which are more nearly circular in section. The keel disappears upon the last lumbar, which has its under surface strongly roughened, especially near the posterior margin.

The epiphyses of all these vertebræ are imperfectly united with the centra, and are deficient in ossification near the center, forming only thin, and, in some cases, narrow rings of bone. The deficiency of ossification increases the apparent concavity of the articular faces of the centrum. These faces also become more oval transversely on the posterior vertebræ, and especially upon the last lumbar vertebra.

The neural canal in all the lumbar vertebræ is large, but has been considerably reduced, in the vertebræ of this specimen, by crushing.

The zygapophyses in the lumbar region are strongly articulated together. The pre-zygapophyses present a curved surface, bending around, and firmly grasping, the semi-cylindrical post-zygapophyses, which are inserted into them. This form of articulation is found among living Artiodactyls, and existed also in the Oreodons of the Miocene; while in the Perissodactyl group, and in Proboscidians, the zygapophyses of this region are loosely applied to each other by nearly flat surfaces.

The keel on the under surface of the centrum is stout and short on the second vertebra from the sacrum, where it first appears in this specimen, and is strongest on the anterior part of the centrum. On the next preceding vertebra, it is somewhat thinner, but more elongated, extending along the whole under surface of the centrum. On the fourth vertebra from the sacrum, it becomes thin, and even sharp in front.

The transverse processes are flattened, especially above, and directed nearly horizontally outward. They are much more elongated than in the mastodon, and appear to have been proportionally much stronger than in the tapir.

The principal dimensions of four lumbar vertebræ of the type specimen of *Dinoceras mirabile* are as follows:

Measurements of Fourth Lumbar Vertebra from Sacrum. (*Dinoceras mirabile*, No. 1036.)

	m.
Length of centrum (anterior epiphysis wanting),	.080
Vertical diameter of centrum,	.087
Vertical diameter of posterior face of centrum,	.075
Transverse diameter of posterior face of centrum (approximate),	.088

Measurements of Third Lumbar Vertebra from Sacrum. (*Dinoceras mirabile*, No. 1036.)

	m.
Length of centrum,	.085
Transverse diameter of anterior epiphysis,	.091
Vertical diameter of anterior epiphysis,	.080
Transverse diameter of posterior epiphysis,	.091
Vertical diameter of posterior epiphysis,	.078

Measurements of Second Lumbar Vertebra from Sacrum. (*Dinoceras mirabile*, No. 1036.)

	m.
Length of centrum,	.086
Transverse diameter of anterior epiphysis (approximate),	.090
Vertical diameter of anterior epiphysis,	.080
Transverse diameter of posterior epiphysis (approximate),	.095
Vertical diameter of posterior epiphysis,	.083

Measurements of last Lumbar Vertebra. (*Dinoceras mirabile*, No. 1036.)

	m.
Length of centrum,	.083
Transverse diameter of anterior epiphysis (approximate),	.095
Vertical diameter of anterior epiphysis,	.080
Transverse diameter of posterior epiphysis (approximate),	.105
Vertical diameter of posterior epiphysis,	.075

CHAPTER VII.

THE FORE LIMBS.

(Plates XXVII–XXXVIII, LV, and LVI.)

THE limb bones in the *Dinocerata* are nearly or quite solid, and this is true of all the skeleton, a portion of the skull alone excepted.

The fore limbs in the *Dinocerata* have a general resemblance to those of Proboscidians. The different segments, however, are more inclined to each other, and the bones that compose them are stouter, and more massive.

THE SCAPULA. (Plate XXVII.)

The scapula of *Dinoceras mirabile*, in its general form, is similar to that of the elephant. It is triangular in outline, with the anterior, or coracoid, border slightly longer than either of the other two margins, which are about equal to each other, if the glenoid border be considered as including the glenoid cavity. The coracoid border is excavated by a broad rounded emargination, just above the coracoid process, but beyond this sinus, it runs nearly straight to the apex of the bone, which is more acute than in the mastodon.

The supra-scapular border is moderately curved throughout, and the posterior angle appears to be less acute than in the Proboscidians. The glenoid border is nearly in a line with the glenoid cavity, so that the constriction above the cavity is scarcely evident in the posterior margin of the bone.

The external surface of the scapula is divided into two unequal fossæ. The anterior of these, or pre-scapular fossa, extends the entire length of the bone, but is less than half as wide as the post-scapular fossa, from which it is divided by a thick and stout spine. The latter is less elevated than in the elephant and mastodon, and less expanded, but extends farther downward, nearly to the level of the glenoid cavity. It is destitute of the curved posterior process seen in the elephant and mastodon.

The post-scapular fossa is strongly roughened near the posterior angle, which is rounded.

The glenoid cavity is only moderately concave transversely, and somewhat broader behind than before.

The inner surface of the scapula is for the most part smooth, except over a large quadrilateral area in the region of the apex. The supra-scapular border is ossified separately from the body of the bone.

The coracoid is firmly united to the scapula in *Dinoceras mirabile* (number 1215), and forms a rounded salient process, projecting freely in front of the glenoid cavity. Seen from the front, it appears to be tri-lobed in outline.

The main dimensions of the scapula in one specimen of *Dinoceras mirabile* are as follows:

Measurements of Left Scapula. (*Dinoceras mirabile*, No. 1215.)

	m.
Antero-posterior diameter of glenoid cavity,	.115
Transverse diameter of glenoid cavity,	.090
Greatest vertical diameter of scapula,	.575
Greatest horizontal diameter,	.480
Length of coracoid border,	.570
Length of supra-scapular border,	.390
Length of glenoid border,	.350
Height of acromion above glenoid cavity,	.120
Greatest diameter of pre-scapular fossa,	.140
Greatest diameter of post-scapular fossa,	.310

The Humerus.

(Plate XXVIII; and woodcuts 106–107, below.)

The humerus of *Dinoceras* is a strong bone, presenting roughened and tuberculated surfaces, evidently for the attachment of powerful muscles. In this respect, it is in strong contrast with the comparatively smooth femur, and a glance at the structure of the skeleton, as shown in the restorations in Plates LV and LVI, will suggest a reason for this difference.

The hind leg of *Dinoceras*, like that of the elephant, could be straightened, so that the weight of the hinder part of the body was supported by a vertical column of bones, rising from the ankle joint to the pelvis, and comparatively little muscular action was required to keep the bones in the requisite position. The elbow joint, on the contrary, was not capable of sufficient extension to bring the radius and ulna into a line with the humerus, but the weight of the fore part of the body was supported, as in ordinary quadrupeds, by a long column with more or less flexure near the middle. Constant muscular action was therefore necessary to sustain the weight of this part of the body. The heavy and strongly armed head added still more to the muscular efforts required of the fore limbs, during progression, or even while standing at rest.

The proximal end of the humerus (Plate XXVIII, figure 3, *a*) presents a large rounded articular face, or head, more convex antero-posteriorly than from side to side. The axis of the head of the humerus forms an angle of nearly 30° with that of the shaft. This angle, while greater than that seen in the same bone of the elephant, is much less than in most quadrupeds.

The great tuberosity of the humerus is prominent, but not elevated, and is separated, by a shallow and narrow bicipital groove, from the low lesser tuberosity. The great tuberosity is about as large as in the elephant, but does not extend so high, not rising to the head of the humerus. It is strongly tuberculated and roughened, and is continued down the anterior and outer part of the shaft into a prominent ridge below

the middle of the bone. Here it unites with the oblique, and well developed, deltoid ridge, then descends rapidly, and ends in a roughened surface just above, and inside of, the coronoid fossa. The deltoid ridge is strong, oblique, and elongated, as is well shown in the back view of the humerus, Plate XXVIII, figure 3. It does not, however, rise into a hook-like process, as in the rhinoceros. The bicipital groove is single, as in the elephant, and presents no median ridge. The lesser tuberosity is small and low, and wholly below the head, which is broad and extensive, covering much the greater part of the superior aspect of the bone, and extending forward to the bottom of the bicipital groove.

The shaft of the humerus is most constricted at a point nearly three-fourths of the way toward the distal end, and here is distinctly triangular in section, one of the angles projecting forward, as seen in Plate XXVIII, figure 1. Above and below this point, the shaft expands, and is more flattened, especially distally. Here it is excavated in front, as usual, by a large rounded and deep coronoid fossa, placed well toward the outer, or radial, side, as shown in Plate XXVIII, figure 1. The posterior surface is hollowed out, medially, by a comparatively shallow anconeal fossa, as shown in figure 3 of the same Plate. The coronoid fossa in some specimens (number 1224) is even deeper than the anconeal, and is always distinct and rounded. The anconeal fossa is also rounded in general outline, median in position, and is carried but little below the trochlear articular face.

The posterior surface of the humerus is bounded, on the inner side, by a ridge running almost the entire length of the shaft. This ridge commences above, near the posterior part of the lesser tuberosity, and the postero-internal angle of the head, and runs nearly straight down the shaft of the humerus, terminating in an expanded and tubercular tract, on the inner condyle. On this ridge, and about the middle of the shaft, nearly opposite the strongest part of the deltoid ridge, is another roughened area, often, as in the specimen figured (Plate XXVIII, figures 1, 2 and 3), rising into a distinct trochanter-like eminence, apparently for the insertion of the *latissimus dorsi* muscle. At the lower end of the humerus, this ridge

ends in a large and prominent inner condyle, which does not, however, extend far back of the trochlear surface, as seen in Plate XXVIII, figure 1, *a*.

The outer condyle is nearly on the same level as the inner, and extends to about the same distance laterally, from the axis of the bone, as seen in Plate XXVIII, figures 1 and 3. Above, it descends rapidly to the shaft of the bone, and presents only a short and moderately rugose, or nearly smooth, supinator ridge.

The trochlear articulation considerably resembles that of the elephant, but is placed a little more obliquely to the axis of the bone. The radius articulated, during life, with the whole of the anterior part of this surface, and the ulna, with the whole of the posterior part, the former bone being, at the proximal end, in front of the latter, and scarcely at all on the outer side. The outer part of the trochlear surface is more rounded in both directions than the inner, the surface of which is only moderately curved in a transverse direction.

The shaft of the humerus is more or less cancellated within, as shown in the woodcuts, figures 106 and 107, but is destitute of any medullary cavity.

FIG. 106.

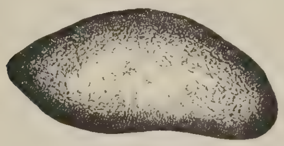


FIG. 107.

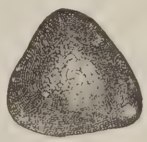


FIGURE 106.—Section of humerus of *Dinoceras mirabile*, Marsh (No. 1215); near proximal end.
FIGURE 107.—Section of humerus of *Dinoceras mirabile* (No. 1208); below middle.
Both figures are one-fourth natural size.

Measurements of the humerus in four individuals of *Dinoceras* are as follows:

Measurements of Left Humerus. (*Dinoceras mirabile*, No. 1245.)

	m.
Total length of humerus,	.555
Antero-posterior diameter of head,	.136
Transverse diameter of head,	.120
Greatest diameter of proximal end,	.220
Least antero-posterior diameter of shaft,	.070
Least transverse diameter of shaft,	.080

	m.
Transverse diameter, through condyles,	.200
Transverse diameter of trochlear surface,	.127
Antero-posterior diameter of trochlear surface, ulnar side,	.109
Antero-posterior diameter of trochlear surface, radial side,	.091
Antero-posterior diameter of trochlear surface, least,	.078
Thickness of bone between coronoid and anconeal fossæ,	.016

Measurements of Left Humerus. (*Dinoceras mirabile*, No. 1208.)

	m.
Least antero-posterior diameter of shaft,	.064
Transverse diameter, through condyles,	.184
Transverse diameter of trochlear surface,	.124
Antero-posterior diameter of trochlear surface, ulnar side,	.100
Antero-posterior diameter of trochlear surface, radial side,	.095
Antero-posterior diameter of trochlear surface, least,	.080
Thickness of bone between coronoid and anconeal fossæ,	.018

Measurements of Right Humerus. (*Dinoceras mirabile*, No. 1212.)

	m.
Least antero-posterior diameter of shaft,	.058
Transverse diameter through condyles,	.183
Transverse diameter of trochlear surface,	.115
Antero-posterior diameter of trochlear surface, ulnar side,	.098
Antero-posterior diameter of trochlear surface, radial side,	.080
Antero-posterior diameter of trochlear surface, least,	.072
Thickness of bone between coronoid and anconeal fossæ,	.014

Measurements of Right Humerus. (*Dinoceras mirabile*, No. 1215.)

	m.
Antero-posterior diameter of head,	.140
Transverse diameter of head,	.138
Greatest diameter of proximal end,	.220
Antero-posterior diameter of trochlear surface, ulnar side,	.116

The Forearm. (Plates LV and LVI.)

The two bones of the forearm in the *Dinocerata* are quite distinct throughout in all the specimens observed, and, exclusive of the olecranon process of the ulna, differ but little in size. The articular surface for the humerus is formed in about equal parts by each bone, except that it is medially produced backward on the ulna upon the beak of the olecranon.

The distal articular face for the carpus was borne more by the radius than the ulna, but the inequality, in size, of the articular faces was comparatively slight. The lunar articulated distinctly with both bones.

The articular surfaces of the radius and the ulna for each other were nearly parallel with the axes of those bones, and allowed of little else than a slight antero-posterior gliding motion. The roughened and co-adapted surfaces of the bones indicate that, during life, all movements of pronation and supination were prevented by powerful ligaments.

The radius does not appear so distinctly to cross the ulna as in the Proboscidians, being, at the upper end, in front of that bone, and proportionally much larger, then passing down obliquely inward to a position within the distal end of the ulna.

The proportion of the two bones to each other is much nearer that seen in the rhinoceros and hippopotamus, than that in the elephant.

The Radius. (Plate XXIX; and woodcuts 108–109, below.)

The radius in *Dinoceras* is a strong bone, with its shaft about equal in size to that of the ulna. It is considerably larger than that bone at the lower end, and smaller at the upper end.

The head, or superior articular face, occupies the entire surface of the proximal end. This surface is elongate oval in outline, the long diameter being placed transversely, and nearly twice as great as the short diameter. The latter is antero-posterior in direction, in the ordinary, nearly vertical position of the bone. It crosses the surface of the bone nearly in the middle, instead of toward the inner side of the middle, as in most Ungulates. Antero-posteriorly, the articular surface is concave throughout, but transversely, it is convex on the inner side, and concave on the outer side of the middle line. The inner half of the articular surface is thus traversed by a low antero-posterior ridge, or elevation, which moves upon the groove in the distal articular face of the humerus.

The proximal surface of the radius differs from that of the elephant in being proportionally much larger, and extending quite across the humeral articular surface. It differs from that of the tapir, and the hippopotamus, in having only a single antero-posterior ridge, as in the rhinoceros. It still differs from that of the rhinoceros, in the fact, that a transverse section

is concave in its outer half, and convex in its inner half, while in the rhinoceros, such a section is concave at each end, and convex only near the median portion.

On the side of the radius toward the ulna, is a narrow articular surface for that bone, becoming broader toward the outer end.

The shaft of the radius is smallest at a point about one-third of the way from the proximal, toward the distal end. Above this point, the bone expands rather rapidly toward the head. It is much roughened, especially on the side toward the ulna, with which, however, it forms no bony union; nor are the bones roughened, or grooved for close adaptation to each other, as in the tapir and rhinoceros. The bicipital tuberosity is well developed, and placed rather low down on the side of the shaft, instead of on the front part of it. The distal end of the shaft is large, rough, and oblique, and presents no smooth grooves for tendons.

The distal articular face is divided by a median ridge into two sub-equal facets, for the scaphoid and lunar bones of the carpus. These facets are confluent along the summit of the median ridge. That for the scaphoid is semi-circular in outline, and concave in both directions, while that for the lunar is four-sided, much broader in front than behind, and concave throughout. Near the back part of the ulnar side of this facet, the articular face is continued into a small tract on the lateral surface of the radius, where it comes in contact with the ulna.

The shaft of the radius has an interior cancellated structure, as shown in the figures below, but no medullary cavity

Fig. 108.

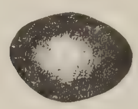


Fig. 109.

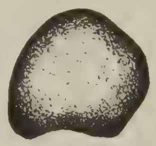


Figure 108.—Section of radius of *Dinoceras mirabile*, Marsh (No. 1195).
Figure 109.—Section of radius of *Dinoceras mirabile*, Marsh (No. 1234).
Both figures are one-fourth natural size.

Measurements of the radius in three individuals of *Dinoceras* are the following:

Measurements of Left Radius. (*Dinoceras mirabile*, No. 1208.)

	m.
Total length of radius,	.380
Greatest diameter of proximal end,	.098
Antero-posterior diameter of proximal end,	.061
Least diameters of shaft,	.032–.053
Transverse diameter of distal end,	.102
Antero-posterior diameter of distal end,	.080
Diameters of articulation for humerus,	.052–.094
Antero-posterior diameter of face for scaphoid,	.055
Transverse diameter of face for scaphoid,	.039
Antero-posterior diameter of face for lunar,	.056
Transverse diameter of face for lunar,	.045
Transverse diameter of distal articular surfaces,	.082

Measurements of Left Radius. (*Dinoceras mirabile*, No. 1206.)

	m.
Total length of radius,	.254
Greatest diameter of proximal end,	.116
Antero-posterior diameter of proximal end,	.071
Least diameters of shaft,	.062–.041
Transverse diameter, distal end,	.011
Antero-posterior diameter, distal end,	.097
Diameters of articulation for humerus,	.060–.108
Antero-posterior diameter of articulation for scaphoid,	.065
Transverse diameter of articulation for scaphoid,	.040
Antero-posterior diameter of articulation for lunar,	.065
Transverse diameter of articulation for lunar,	.055
Transverse diameter of distal articular surfaces,	.093

Measurements of Right Radius. (*Dinoceras*, No. 1548.)

	m.
Length of radius,	.400
Greatest diameter of proximal end,	.112
Antero-posterior diameter of proximal end,	.070
Least diameters of shaft,	.063–.035
Transverse diameter of distal end,	.108
Antero-posterior diameter of distal end,	.090
Diameters of articulation for humerus,	.060–.104
Transverse diameter of articulation for scaphoid,	.047
Antero-posterior diameter of articulation for lunar,	.055
Transverse diameter of articulation for lunar,	.045
Transverse diameter of distal articular surfaces,	.092

The Ulna. (Plate XXX; and woodcuts 110–111, below.)

The ulna in the *Dinocerata* is a solid and heavy bone, longer than the radius, as usual, by the length of the olecranon process. Except near the distal end, it is larger and stouter than that bone, to which it was united in life by ligaments only, but in such a manner as to allow of little motion between them. The shaft of the ulna always made, even at its utmost extension, a distinct angle with that of the humerus.

The ulna in *Dinoceras* is proportionally less robust than in the elephant. Its distal end is comparatively smaller than in that animal, and, at the proximal end, a much smaller proportion of the articular surface for the humerus is furnished by the ulna.

The olecranon process is robust, as in the Proboscidians, but it is carried farther above the articular surface, and less directly behind it, than in that group. It is much higher within than without, and posteriorly, it is strongly roughened as low down as the middle of the humeral articulation. It is only moderately produced backward, and descends into a broad ridge, insensibly blending below with the shaft of the bone.

Below the humeral articular surface, the shaft of the ulna is sub-triangular in section, or, near the distal end, somewhat quadrilateral. Along the posterior and outer side of the bone, is a rounded ridge, running from the olecranon process above, to the outer angle of the articular face below.

The face by which the ulna is applied to the radius is broadly excavated, and strongly roughened above, where it is nearly on the front surface of the bone. It is moderately flattened along the shaft of the bone, and is carried around to the inner surface toward the distal end, where it is broad, flat, and distinctly roughened.

The anterior face of the bone is also flattened near the distal end, and separated from the outer face by a ridge, which extends upward to near the middle of the shaft. The postero-external face of the bone is flattened, or only moderately rounded, and is somewhat excavated behind the lower part of the humeral articulation.

This articulation presents a striking difference in direction from that seen in the corresponding face on the ulna of the elephant and mastodon. It is so placed on the shaft of the bone as to look almost directly forward, and only very slightly upward, instead of looking nearly upward, as in the mastodon. It forms, comparatively, a much smaller part of the face for the humeral trochlea.

In shape, this articulation is distinctly tri-lobate. One rounded lobe, convex from side to side, runs backward and upward to the summit of the beak of the olecranon. A second, and large lobe, moderately concave in both directions, runs inward, articulating with the ulnar portion of the trochlea of the humerus. An outer, small and flattened, lobe articulates with the posterior part of the radial surface of the trochlea. The front, or lower, outline of the articular face is moderately concave, and adapted to the surface of the radius by a narrow face, becoming wider toward each extremity.

The distal end of the ulna is terminated by an articular surface, which is somewhat quadrant-shaped. The inner and posterior outlines are nearly straight, and meet at a right angle, while the anterior and outer margins are formed by a curved line.

This face is convex in an antero-posterior direction, strongly so behind. In a transverse direction, it is moderately concave, except near the inner edge, where it is broadly beveled off, for union with the lunar bone of the carpus.

Much the larger part of the distal articular face of the ulna articulated, during life, with the pyramidal bone, or the cuneiform bone of many anatomists.

Posteriorly, a surface was presented for the pisiform, and, on the inner side, a narrow beveled surface united with the lunar bone.

Farther within, and on the surface of the shaft of the bone, a small surface was presented to the radius, although the two bones, as already stated, were strongly fixed, during life, in their relation to each other.

The inner texture of the shaft of the ulna is similar to that of the radius, as indicated in the sections represented below, figures 110 and 111.

FIG. 110.

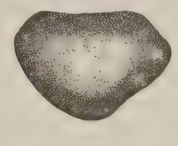


FIG. 111.

FIGURE 110.—Section of ulna of *Dinoceras lucare*, Marsh (No. 1038).
FIGURE 111.—Section of ulna of *Dinoceras mirabile*, Marsh (No. 1548).
Both figures are one-fourth natural size.

The principal dimensions of the ulna in three individuals of *Dinoceras* are as follows:

Measurements of Left Ulna. (*Dinoceras mirabile*, No. 1206.)

	m.
Total length of ulna,	.530
Diameters of proximal end,	.095–.140
Transverse diameter of shaft, behind humeral articular face,	.055
Diameter of shaft, through humeral articular face,	.097
Diameters of shaft, near the middle,	.057–.081
Antero-posterior diameter of shaft, near distal end,	.085
Transverse diameter of shaft, near distal end,	.067
Transverse diameter of humeral articulation, greatest,	.143
Transverse diameter of humeral articulation, least,	.060
Antero-posterior diameter of humeral articulation, at the middle,	.085
Antero-posterior diameter of humeral articulation, inner lobe,	.063
Antero-posterior diameter of humeral articulation, outer lobe,	.045
Transverse diameter of distal articular surface,	.076
Antero-posterior diameter of distal articular surface,	.070
Least and greatest diameters of distal articular surface,	.067–.097

Measurements of Right Ulna. (*Dinoceras mirabile*, No. 1232.)

	m.
Total length of ulna,	.555
Diameters of proximal end,	.098–.130
Transverse diameter of shaft, behind humeral articulation,	.065
Diameter of shaft, through humeral articulation,	.103
Diameters of shaft, near the middle,	.067–.077
Antero-posterior diameter of shaft, near distal end,	.095
Transverse diameter of shaft, near distal end,	.084
Least transverse diameter of humeral articulation,	.058
Antero-posterior diameter of humeral articulation, at the middle,	.086

	m.
Antero-posterior diameter of humeral articulation, inner lobe,	.066
Transverse diameter of distal articular surface,	.073
Antero-posterior diameter of distal articular surface,	.061
Greatest diameter of distal articular surface,	.090

Measurements of Right Ulna. (*Dinoceras lucare*, No. 1038.)

	m.
Diameters of proximal end of ulna (approximate),	.070-.103
Diameter of shaft, behind humeral articulation,	.052
Diameter of shaft, through humeral articulation,	.088
Greatest transverse diameter of humeral articulation,	.125
Least transverse diameter of humeral articulation,	.052
Antero-posterior diameter of humeral articulation, at the middle,	.090
Antero-posterior diameter of humeral articulation, inner lobe,	.062
Antero-posterior diameter of humeral articulation, outer lobe,	.038

CHAPTER VIII.

THE FORE LIMBS. (Continued.)

(Plates XXXI–XXXVIII, LIV, LV and LVI).

The fore foot in all the *Dinocerata* is larger than the hind foot. The bones composing it are comparatively short and massive. There were five well developed digits, as in Proboscidians, but the carpal bones were interlocked with the metacarpals, as in Perissodactyls. The general appearance of the fore foot in *Dinoceras mirabile* is well shown in Plate LIV, figure 1. The hind foot is represented in figure 2 of the same Plate. The feet were plantigrade, as in the elephant, and in their more important characters were much like those of *Coryphodon*.

THE CARPAL BONES.

(Plates XXXI–XXXIV; and woodcuts 112–124, below.)

There are eight separate carpal bones in the fore foot of all the *Dinocerata*, and a ninth, the central bone, may be separate in very young animals, and, in adults, either lost or consolidated with the scaphoid, or the trapezoid.

The Scaphoid.

(Plate XXXI, figures 1–6, Plate LIV, figure 1, *s*;
and woodcuts 112–113, below.)

The scaphoid in the *Dinocerata* is a peculiar bone of characteristic shape. It is quite large, its length, along the axis of the limb, being greater than that of any other bone of the carpus. Proximally, it presents a strongly rounded, almost hemispherical surface, for articulation with the radius. This articular face covers the entire proximal end of the bone, and is oblique to its axis, the side toward the lunar being much higher than the opposite side. The ulnar side, in apposition with the lunar, has a proximal articular surface confluent with the radial surface, and extending less than one-fourth the length of the bone.

Distally, the scaphoid presents two confluent articular faces, one for the trapezium, and a second smaller one, somewhat in front of the other, for the trapezoid. These two faces are but indistinctly separated from each other, and are, for most of their extent, convex in both directions.

The ulnar side of the bone also presents two confluent, but well marked, articular surfaces, making an obtuse angle with each other. Of these, the anterior is nearly flat, and joins the lunar. The posterior is more convex, and adapted to the magnum. This face does not reach the anterior angle of the bone, so that the magnum is supported in front by the lunar alone, but articulates behind with the scaphoid also.

The projection supporting these two faces may perhaps represent the central bone, coalesced with the scaphoid. The latter shows no face for a separate central bone.

The two proximal articular faces are well separated from the four at the distal end of the scaphoid bone by a large area of non-articular surface. This tract becomes elevated, and strongly tuberculated, on the exterior side of the bone, while it is smoother, and somewhat excavated, on the side turned toward the lunar and the magnum.

In Plate LIV, figure 1, the scaphoid and lunar bones are slightly out of position, but every anatomist will see their true relations to each other.

The scaphoid in *Dinoceras laticeps* (number 1264), like most others (except number 1208), shows, near the distal portion of the radial side, below the rugose surface, a deep and somewhat oblique depression.

The scaphoid in two specimens of *Dinoceras* are represented in the figures below.

Fig. 112.

Fig. 113

Figure 112.—Left scaphoid of *Dinoceras laticeps*, Marsh (1264); side view.
Figure 113.—Right scaphoid of *Dinoceras mirabile*, Marsh (1200); side view.
r. face for radius; *tm.* face for trapezium; *tr.* face for trapezoid.
Both figures are one-half natural size.

The principal dimensions of the scaphoid in three individuals of *Dinoceras* are as follows:

Measurements of Left Scaphoid. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of longitudinal axis of scaphoid,	.077
Length of transverse axes,	.049–.049
Antero-posterior diameter of radial articular surface,	.051
Transverse diameter of radial articular surface,	.045
Antero-posterior diameter of distal articular surface,	.070
Transverse diameter of distal articular surface,	.044

Measurements of Right Scaphoid. (*Dinoceras mirabile*, No. 1200.)

	m.
Length of longitudinal axis of scaphoid,	.071
Length of transverse axes,	.073–.054
Antero-posterior diameter of radial articular surface,	.046
Transverse diameter of radial articular surface,	.038
Antero-posterior diameter of distal articular surface,	.066
Transverse diameter of distal articular surface,	.038

Measurements of Left Scaphoid. (*Dinoceras laticeps*, No. 1264.)

	m.
Length of longitudinal axis of scaphoid,	.086
Length of transverse axes,	.051–.060
Antero-posterior diameter of radial articular surface,	.060
Transverse diameter of radial articular surface,	.046
Antero-posterior diameter of distal articular surface,	.082
Transverse diameter of distal articular surface,	.050

The Lunar.

(Plate XXXI, figures 7–12, Plate LIV, figure 1, *l*; and woodcuts 114–116, below.)

The lunar bone in the *Dinocerata* (Plate XXXI, figures 7–12) bears some resemblance to the corresponding bone in the elephant, but differs widely from it in having its proximal surface, for articulation with the radius and ulna, convex throughout, instead of being for the most part concave. The distal surface, also, presents two distinct articular faces, instead of being covered with a single large face, as in the elephant.

The exterior surface of the lunar, or the face seen in front when the bone is in its natural position with the other bones of the foot, is represented on Plate XXXI, figure 7. This surface is coarsely roughened, and is widest above. Only a small portion of the edges of any of the articular surfaces can be seen in this view.

The inner angle of the distal end of the lunar in *Dinoceras* (numbers 1215, 1229, and 1230) is truncated by a small face for articulation with the trapezoid bone, as shown in figure 7, and also in woodcut 114, below. On one specimen (number 1575), which may belong to *Uintatherium*, this face is large and convex. In number 1254, the face is smaller than in the specimens figured. The articulation of the lunar with the trapezoid, or perhaps the trapezo-central bone, occurs also in *Coryphodon*, *Mastodon*, and the elephant, especially the African species.

The lateral surface of the bone turned toward the scaphoid, and articulating with it, is shown on Plate XXXI, figure 8. This side has two faces for articulation with the scaphoid. The upper one of these runs along nearly the whole extent of the superior margin of the bone, and is confluent with the surface for articulation with the radius, and hardly to be distinguished from it. A second articular face for union with the scaphoid is broader and more flattened than the first, and extends along rather more than half of the distal margin near its front, or anterior, end. Behind this articular surface, the bone is produced into a short, hook-shaped process sustaining the concave portion of the distal articulations.

The posterior surface of the lunar is shown on the same Plate, figure 9, and presents no articular faces. The lateral surface turned toward the

pyramidal is shown in figure 10. Two narrow and approximate faces are seen on this surface, becoming somewhat wider, and approaching each other behind. These faces vary greatly in the degree to which they are developed in different specimens.

The upper, or proximal, surface is confluent with the ulnar facet, while the lower, or distal, one is continuous with the face for the unciform, but usually well distinguished from it by a ridge.

The proximal surface (figure 11), articulating with the radius, is more or less quadrangular in outline, broader in front, sometimes so much so as to become sub-triangular in outline (number 1218). It is well rounded in both directions throughout, the smooth articular face for radius and ulna being carried over on each side to join both the scaphoid and the pyramidal faces.

Fig. 114.

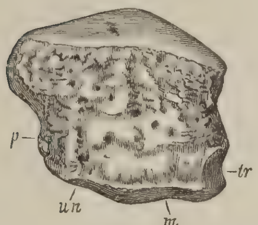


Fig. 115.

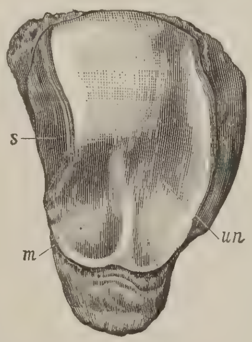


Fig. 116.

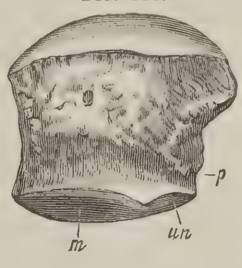


FIGURE 114.—Right lunar of *Dinoceras mirabile*, Marsh (No. 1230); front view.
FIGURE 115.—Left lunar of *Tinoceras ingens*, Marsh (No. 1504); bottom view.
FIGURE 116.—Left lunar of *Tinoceras ingens* (No. 1219); front view.
m. face for magnum; *p.* face for pyramidal; *r.* face for radius; *s.* face for scaphoid; *tr.* face for trapezoid; *un.* face for unciform.
All the figures are one-half natural size.

The distal surface (figure 12) is divided into two articular faces, supporting in part the magnum and the unciform. These faces are confluent, and sometimes hardly to be distinguished in front, but, on the posterior part of the surface, they are separated by a more or less distinct rounded ridge. Both these faces are nearly flat transversely in front, and somewhat concave behind. In an antero-posterior direction, they are convex in front, and concave behind.

In the right lunar of *Dinoceras mirabile* (number 1230), the distal face for articulation with the scaphoid makes less than a right angle with the face for the magnum. instead of an obtuse angle, as in most other specimens.

The lunar bone in *Tinoceras* presents no articular face for the trapezoid, and is much produced posteriorly, thus distinguishing it from the lunar in the genus *Dinoceras*. Its main features are shown in the woodcuts, 115 and 116, above.

The more important measurements of the lunar bone in four individuals of the *Dinocerata* are as follows:

Measurements of Right Lunar. (*Dinoceras mirabile*, No. 1230.)

	m.
Length of longitudinal axis of lunar,	.050
Antero-posterior diameter of proximal end,	.059
Transverse diameter of proximal end,	.056
Antero-posterior diameter of distal end,	.075
Transverse diameter of distal end,	.046

Measurements of Left Lunar. (*Tinoceras ingens*, No. 1503.)

	m.
Length of longitudinal axis of lunar,	.051
Antero-posterior diameter of proximal end,	.061
Transverse diameter of proximal end,	.053
Antero-posterior diameter of distal end,	.083
Transverse diameter of distal end,	.047

In this specimen, the distal face for the scaphoid is quite large, and encroaches on the face for the magnum.

Measurements of Right Lunar. (*Tinoceras ingens*, No. 1504.)

	m.
Length of longitudinal axis of lunar,	.054
Antero-posterior diameter of proximal end,	.062
Transverse diameter of proximal end,	.065
Antero-posterior diameter of distal end,	.088
Transverse diameter of distal end,	.050

Measurements of Left Lunar. (*Tinoceras ingens*, No. 1246.)

	m.
Length of longitudinal axis of lunar,	.061
Antero-posterior diameter of proximal end,	.066
Transverse diameter of proximal end,	.060
Antero-posterior diameter of distal end,	.092
Transverse diameter of distal end,	.053

The Pyramidal.

(Plate XXXII, figures 1–6, Plate LIV, figure 1, *p*; and woodcuts 117–118, below.)

The pyramidal bone in the *Dinocerata* bears a considerable resemblance to the corresponding bone in the elephant, and has, in general, a similar shape, and similar arrangement of articular faces.

Plate XXXII, figure 1, represents the outer, or dermal, surface of the bone, as seen in its natural position in the foot, and shows a portion only of the saddle-shaped articular face for the ulna.

The anterior view of the bone (figure 2) shows but little of the articular faces, although, on the side turned toward the lunar, may be seen a short articular face running along the distal portion of the surface. This face is seen more clearly in figure 3, and is confluent with the lower, or distal, face supporting the unciform, but makes a considerable angle with it.

In the posterior view of the bone (figure 4), the oblique articulation for the pisiform is shown. This articular face, like most of the lateral ones among the carpal bones, is of variable shape, and often fails to show the deep emargination at the side, seen in the specimen figured. Along the upper margin, where this face is confluent with the ulnar articular face, the two are separated by a nearly straight, prominent, rounded ridge.

The proximal surface of the bone (figure 5) shows principally the sub-triangular saddle-shaped face for articulation with the ulna.

The distal surface of the bone (figure 6) presents, also, a somewhat triangular and saddle-shaped face, for the support of the unciform bone, and, in the specimen figured, an additional, distinct, oval, and convex face, giving support to the metacarpal of the fifth digit.

In other specimens, this face is present, and well developed, but confluent with that supporting the unciform, as shown in the woodcuts below, figures 117 and 118.

The pyramidal bone in a second specimen of *Dinoceras*, and in one of *Tinoceras*, is shown in figures 117 and 118, below.

FIG. 117.

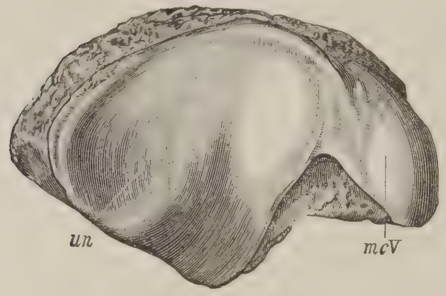


FIG. 118.

FIGURE 117.—Left pyramidal of *Tinoceras ingens*, Marsh (No. 1577); distal end.
FIGURE 118.—Left pyramidal of *Dinoceras mirabile*, Marsh (No. 1230); distal end.
*mc*V. face for fifth metacarpal; *un.* face for unciform.
Both figures are one-half natural size.

The following are the more important dimensions of the pyramidal bone in three specimens of *Dinoceras* and *Tinoceras:*

Measurements of Left Pyramidal. (*Dinoceras mirabile*, No. 1208.)

	m.
Greatest length of longitudinal axis of pyramidal,	.045
Total length of bone,	.098
Least transverse diameter,	.054
Greatest diameter of ulnar articular surface,	.073
Antero-posterior diameter of ulnar articular surface,	.049
Greatest diameter of articular face for unciform,	.064
Antero-posterior diameter of articular face for unciform,	.051
Diameters of face for fifth metacarpal,	.018–.029

Measurements of Left Pyramidal. (*Dinoceras mirabile*, No. 1230.)

	m.
Greatest length of longitudinal axis of pyramidal,	.042
Greatest diameter of bone,	.100
Least transverse diameter,	.062
Greatest diameter of ulnar articular face,	.083
Antero-posterior diameter of ulnar articular face,	.049
Greatest diameter of face for unciform,	.067
Antero-posterior diameter of face for unciform,	.057
Diameter of face for fifth metacarpal,	.026

Measurements of Left Pyramidal. (*Tinoceras ingens*, No. 1577.)

	m.
Greatest length of longitudinal axis of pyramidal,	.050
Greatest diameter of bone,	.113
Least transverse diameter,	.069
Greatest diameter of ulnar articular surface,	.092
Antero-posterior diameter of ulnar articular surface,	.062
Greatest diameter of articular face for unciform,	.080
Antero-posterior diameter of articular face for unciform,	.066

The Pisiform. (Plate XXXII, figures 7–12.)

The pisiform in the *Dinocerata* is a short, stout bone, presenting, as usual, two confluent articular faces, one for the ulna, and the second for the pyramidal.

Plate XXXII, figure 7, represents the surface of the pisiform seen from the side of the skeleton, when the bone is in its natural position, except that the long axis has been placed in a vertical, instead of an oblique, position. Neither of the articular faces can be seen in this figure.

The inner side of the bone, or that turned toward the pyramidal (figure 8), shows, at its proximal end, a large and somewhat triangular face, flattened, or slightly concave or convex, and extending, in the specimen figured, over more than half the length of the bone, but, in some specimens, it is proportionally shorter.

Figure 9, which gives the view opposite to that in figure 7, shows this articular face, seen obliquely.

The proximal end of the bone (figure 11) is nearly covered by a triangular articular face for union with the ulna. This face, in the specimen figured, is flat in one direction, and distinctly convex in the other, but another specimen of the same bone has this face distinctly convex in both directions.

Distally, the pisiform is strongly roughened and tuberculated, with the end rounded, as shown in figure 12.

The principal measurements of two specimens of the pisiform bone in *Dinoceras mirabile* are given below.

Measurements of Right Pisiform. (*Dinoceras mirabile*, No. 1211.)

	m.
Length of pisiform bone,	.061
Greatest transverse diameter,	.050
Least transverse diameter,	.030
Greatest diameter of ulnar articular surface,	.038
Least diameter of ulnar articular surface,	.021
Greatest diameter of face for pyramidal,	.047
Least diameter of face for pyramidal,	.029

Measurements of Right Pisiform. (*Dinoceras mirabile*, No. 1520.)

	m.
Length of pisiform bone,	.065
Greatest transverse diameter,	.045
Least transverse diameter,	.033
Greatest diameter of ulnar articular surface,	.042
Least diameter of ulnar articular surface,	.021
Greatest diameter of face for pyramidal,	.044
Least diameter of face for pyramidal,	.023

The Trapezium.

(Plate XXXIII, figures 1–6, and Plate, LIV, figure 1, *tm.*)

The trapezium in the *Dinocerata* is well developed, being considerably larger than the trapezoid. It presents at each end a large articular face, and a third smaller and much less regular one, for articulation with the trapezoid, on the side turned toward that bone.

The outer, or dermal, surface of the bone (Plate XXXIII, figure 1), when viewed in its natural position in the foot, is rough and tuberculated. The posterior view (figure 2), and the anterior view (figure 4), likewise show no articular faces. Figure 3, representing the surface turned toward the trapezoid, presents an irregular, smooth face along the upper margin. This face differs in size and proportions in different specimens, and in life moved upon a corresponding surface on the trapezoid.

The proximal end of the bone (figure 5) is almost entirely covered by the articular face for the scaphoid. This face, nearly semi-circular in outline, is flattened in one direction, slightly concave in the other, and confluent along the straight margin with the face for the trapezoid.

The distal end (figure 6) presents a semi-oval articular face, not extending quite to the anterior part of the bone, and supporting in life the well developed, short, first metacarpal. This articular face is somewhat saddle-shaped, being convex along its short diameter, and slightly concave lengthwise.

The main dimensions of the trapezial bone in two specimens of the *Dinocerata* are given below.

Measurements of Left Trapezium. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of longitudinal axis of trapezium,	.036
Greatest horizontal diameter,	.062
Least horizontal diameter,	.033
Longest diameter of proximal articular face,	.044
Transverse diameter of proximal articular face,	.026
Longest diameter of distal articular face,	.048
Transverse diameter of distal articular face,	.026

Measurements of Right Trapezium. (*Tinoceras ingens*, No. 1219.)

	m.
Length of longitudinal axis of trapezium,	.037
Greatest horizontal diameter,	.068
Least horizontal diameter,	.031
Greatest diameter of proximal articular face (approximate),	.045
Transverse diameter of proximal articular face,	.032
Greatest diameter of distal articular face,	.053
Transverse diameter of distal articular face,	.030

The Trapezoid.

(Plate XXXIII, figures 7–12, Plate LIV, figure 1, *tr*; and woodcuts 119–120, below.)

The trapezoid is a small bone in the *Dinocerata*, being much the smallest of the carpals, with the exception of the pisiform, and perhaps also of the central, if separate. The general shape of the bone is that of a blunt, nearly square, wedge, the large end being presented to the superior, or anterior, surface of the foot.

This end of the bone is represented in Plate XXXIII, figure 7, and shows nearly all that can be seen of it when in its natural position with

the other bones of the foot. The surface is strongly rugose, and, in this view, nothing can be seen of the articular faces.

The lateral surface turned toward the trapezium presents an articular face for union with that bone. An ordinary form of this face is shown in figure 8, but it is of variable form and size. Sometimes it even extends obliquely across the lateral surface of the bone, and becomes more or less widely confluent with the articulation for the metacarpal, along the anterior part of its lateral border, as in woodcut 119 below.

Fig. 119.

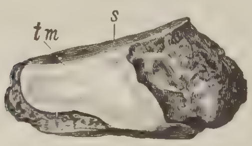


Fig. 120.

Figure 119.—Left trapezoid of *Dinoceras mirabile*, Marsh (No. 1230); side view.
Figure 120.—The same bone; distal end.
mcII. face for second metacarpal; *s.* face for scaphoid; *tm.* face for trapezium.
Both figures are one-half natural size.

The posterior, or palmar, aspect of the bone (figure 9) shows its wedge-like form, but the articular faces visible are seen only obliquely.

The side turned toward the magnum (figure 10) has an articular surface extending across the bone. Usually, this surface is near the anterior part of the bone, and sometimes, as in the specimen figured, is more or less interrupted at the middle by a ridge. This surface may also be broadly continued to the posterior, or palmar, end of the scaphoid articular face, as in number 1505.

The upper ulnar angle of this specimen is rounded for articulation with the lunar. This portion of the bone may represent the central, coalesced with the trapezoid, as in the existing *Dendrohyrax.*

The proximal articular face (figure 11), joining the scaphoid bone, is narrowly oval in outline, broader in front than behind, and more or less concave in both directions.

The distal face is somewhat similar in shape to the proximal, but sometimes shorter and broader, and is slightly convex in one, or both directions.

The principal dimensions of the trapezoid bone in two individuals of *Dinoceras*, and one of *Tinoceras*, are as follows:

Measurements of Left Trapezoid. (*Dinoceras mirabile*, No. 1208.)

	m.
Greatest vertical extent of trapezoid,	.036
Length of vertical axis,	.022
Greatest (antero-posterior) diameter,	.058
Transverse diameter, near the middle,	.029
Antero-posterior diameter of proximal articular face,	.049
Transverse diameter of proximal articular face,	.027
Antero-posterior diameter of distal articular face,	.051
Transverse diameter of distal articular face,	.025

Measurements of Left Trapezoid. (*Dinoceras mirabile*, No. 1230.)

	m.
Greatest vertical extent of trapezoid,	.034
Length of vertical axis,	.023
Greatest (antero-posterior) diameter,	.067
Transverse diameter,	.035
Antero-posterior diameter of proximal articular face,	.050
Transverse diameter of proximal articular face,	.029
Antero-posterior diameter of distal articular face,	.043
Transverse diameter of distal articular face,	.035

Measurements of Right Trapezoid. (*Tinoceras ingens*, No. 1219.)

	m.
Greatest vertical extent of trapezoid,	.038
Length of vertical axis,	.025
Greatest (antero-posterior) diameter,	.063
Transverse diameter, near the middle,	.033
Antero-posterior diameter of proximal articular face,	.048
Transverse diameter of proximal articular face,	.030
Antero-posterior diameter of distal articular face,	.050
Transverse diameter of distal articular face,	.029

The Magnum.

(Plate XXXIV, figures 1–6, Plate LIV, figure 1; and woodcuts 121–122, below.)

The magnum in the *Dinocerata* is proportionally a much smaller bone than in the elephant, and has a much greater difference in the length of the vertical axis in the anterior and posterior parts of the bone, than in that animal.

An anterior view of the magnum, when in its natural position among the other bones of the carpus, is seen in Plate XXXIV, figure 1. The dermal surface is pentagonal in outline, rough and tuberculated, while behind and above it, is seen obliquely a portion of the smooth articular face by which the bone articulates with the lunar and scaphoid bones of the preceding carpal series.

The lateral surface of the magnum (figure 2) turned toward the trapezoid varies in the shape and structure of its articular face for that bone. This face is frequently more or less divided, as in the specimen figured, or the articular face may be on the distal part of the bone, not extending across to the scaphoid face. A large proportion of the posterior part of the face for the scaphoid is seen in the same figure. This face is strongly saddle-shaped. In the same view, is seen a third articular face, for the support, in part, of the second metacarpal. This face is narrow, and elongated from before backward, and, in the natural position of the bone, is directed obliquely downward, toward the radial side of the foot.

The posterior, or palmar, surface of the magnum (figure 3) is rough, but rounded over, and shows at the upper, or proximal, end a portion of the articular face for the lunar, carried well over on the posterior face of the bone.

The lateral surface (figure 4) turned toward the unciform presents a considerable, but varying, articular surface for union with that bone. In the specimen figured (number 1208), there is a large area extending along the entire length of the proximal, or lunar, articular face, contracting near the middle, but expanding anteriorly, so as to extend nearly, or quite, across the lateral surface of the bone. In many specimens (numbers 1195, 1218, 1219, 1230, 1516), this area is confluent with the distal articular face for the third metacarpal. In the specimen figured, however, it is, interrupted by a slight ridge at this point, beyond which, it is continued well along the margin of this articular face posteriorly. This distal backward extension of the articular face is not present in all specimens (numbers 1195, 1230), and is often much narrower than in the specimens figured (numbers 1211, 1219)

The proximal surface of the magnum (figure 5), by which it bears upon the scaphoid and lunar bones, is much elevated posteriorly in the region of the face for the lunar, but the two facets are so perfectly confluent as scarcely to be distinguished. The face for the scaphoid is strongly saddle-shaped, and does not extend quite to the anterior margin of the bone.

The face for the lunar is nearly flat, or slightly convex from side to side, sigmoid from before backward, and is carried well over to the posterior face of the bone. The variation in the form of this curve is considerable, but the specimen figured on the Plate may be regarded as a fair average, while extreme forms are represented in woodcuts 121 and 122, below.

FIG. 121.

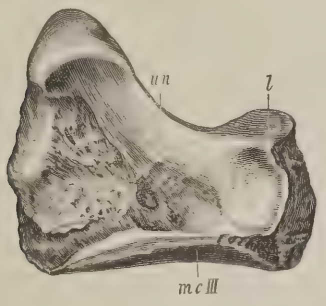


FIG. 122.

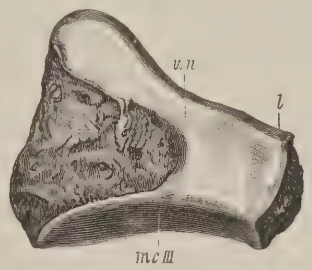


FIGURE 121.—Right magnum of *Dinoceras mirabile*, Marsh (No. 1211); side view.
FIGURE 122.—Right magnum of *Dinoceras mirabile*, (No. 1230); side view.
l. face for lunar; *mc*III. face for third metacarpal; *un.* face for unciform.
Both figures are one-half natural size.

The distal face of the magnum (Plate XXXIV, figure 6) is mostly occupied by an elongated articular face for the support, in great part, of the third metacarpal. This face is more or less moderately concave from before backward, slightly convex transversely, and is usually a little broader in front than behind. It is separated by a rounded ridge from the confluent, narrower and oblique, face lying along its radial side, and aiding in the support of the second metacarpal.

The dimensions of the magnum bone of four individuals of the *Dinocerata* are as follows:

Measurements of Left Magnum. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of longitudinal axes of magnum,	.033–.062
Antero-posterior diameter,	.066
Transverse diameter,	.038
Antero-posterior diameter of proximal articular face,	.058
Transverse diameter of proximal articular face,	.030
Antero-posterior diameter of face for second metacarpal,	.046
Transverse diameter of face for second metacarpal,	.018
Antero-posterior diameter of face for third metacarpal,	.057
Transverse diameter of face for third metacarpal,	.025

Measurements of Right Magnum. (*Dinoceras mirabile*, No. 1211.)

	m.
Length of longitudinal axes of magnum,	.036–.069
Antero-posterior diameter,	.080
Transverse diameter,	.039
Antero-posterior diameter of proximal articular face,	.073
Transverse diameter of proximal articular face,	.032
Antero-posterior diameter of face for second metacarpal,	.060
Transverse diameter of face for second metacarpal,	.020
Antero-posterior diameter of face for third metacarpal,	.064
Transverse diameter of face for third metacarpal,	.027

Measurements of Right Magnum. (*Dinoceras mirabile*, No. 1195.)

	m.
Length of longitudinal axes of magnum,	.032–.062
Antero-posterior diameter,	.063
Transverse diameter,	.034
Antero-posterior diameter of proximal articular face,	.065
Transverse diameter of proximal articular face,	.027
Antero-posterior diameter of face for second metacarpal,	.050
Transverse diameter of face for second metacarpal,	.018
Antero-posterior diameter of face for third metacarpal,	.055
Transverse diameter of face for third metacarpal,	.022

Measurements of Left Magnum. (*Dinoceras mirabile*, No. 1218.)

	m.
Length of longitudinal axes of magnum,	.033–.069
Antero-posterior diameter,	.075
Transverse diameter,	.041
Antero-posterior diameter of proximal articular face,	.068
Transverse diameter of proximal articular face,	.034
Antero-posterior diameter of face for second metacarpal,	.049
Transverse diameter of face for second metacarpal,	.018
Antero-posterior diameter of face for third metacarpal,	.063
Transverse diameter of face for third metacarpal,	.031

The Unciform.

(Plate XXXIV, figures 7–12, Plate LIV, figure 1, *un*; and woodcuts 123–124, below.)

The unciform in the *Dinocerata* is similar, in general shape and proportions, to that of Proboscidians, but is less oblique, and presents three sub-equal articular faces on its distal surface, instead of two, as in the elephant.

The exterior, or dermal, surface of the bone (Plate XXXIV, figure 7) is moderately roughened and pitted, and is regularly rounded, in the horizontal direction, through an arc but little short of a quadrant. From above downward, the surface is nearly plane.

The inner surface (figure 8), or that turned toward the magnum, is bordered above, in part, and partly below, by a smooth articular face for union with that bone. The amount and disposition of this surface vary in a manner corresponding with the faces for its union with the magnum, as before described. The proximal and anterior portions of this face are the most constant, and may be confluent along the whole margin of the proximal articular face, or may be interrupted near the middle (number 1195). The proximal part of this face may extend quite across, so as to become confluent with the face for the third metacarpal, and may then, as in the specimen figured, border that face throughout its extent, or it may even fail to reach the lower, or distal, margin of the bone at all (numbers 1509, 1525).

The posterior, or postero-interior, face of the unciform (figure 9) is quite irregular, and, when not encroached upon by articular faces, is moderately roughened.

The outer side of the bone (figure 10) is short from above downward, allowing the articular face for the pyramidal to approach that for the fifth metacarpal, as in the elephant. These faces may even be confluent for a short distance across this surface (number 1211), as in figure 123, below, or may be separated (numbers 1509 and 1525), as in figure 124.

The proximal face (Plate XXXIV, figure 11) is obliquely saddle-shaped, and presents two confluent, but distinguishable, faces, one for the lunar, and one much larger, for the pyramidal.

The face for the lunar lies along the inner, or radial, side of the proximal surface, and is sigmoid from before backwards, and transversely more or less convex. Its posterior half is considerably elevated above the anterior, to fit into a corresponding excavation in the lunar.

The face for articulation with the pyramidal is somewhat in the form of a quadrant, one side being confluent with the face for the lunar, the other side running along the outer, or posterior, margin of the bone, while the curve forms the upper limit of the dermal surface. This face is strongly saddle-shaped, concave antero-posteriorly, and convex from side to side.

The distal surface of the unciform (figure 12) bears three concave articular faces for the support of the third, fourth, and fifth metacarpals. Of these, the inner is the smallest, triangular in outline, only slightly concave, and aids the magnum in the support of the middle, or third, metacarpal.

The second, or median, articular face is the largest, and is more deeply concave than the first. It extends antero-posteriorly quite across the distal end of the bone, but is much broader in front than behind. It supports the fourth metacarpal.

The third articular face, situated upon the outer, or ulnar, side of the distal end of the unciform, is more strongly concave antero-posteriorly than either of the others, and is nearly as broad behind, or on its palmar margin, as in front. It is oblique to the axis of the bone, and, as already mentioned, may even be confluent for a short distance with the proximal face for the pyramidal, as shown in figure 123, below.

The unciform bone in two individuals of the *Dinocerata* is represented in the woodcuts below. The specimens figured show marked differences, but whether these are constant in all the species of the two genera cannot at present be determined. This is the case, also, with other carpal bones.

Fig. 123.

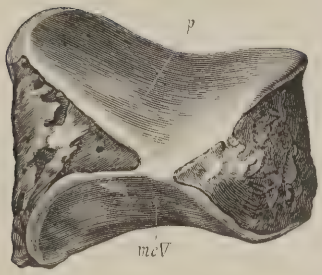


Fig. 124.

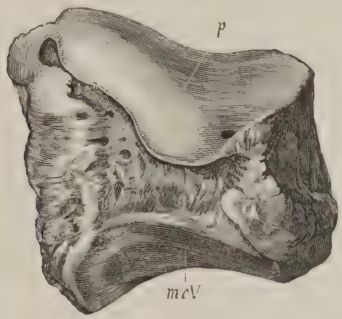


Figure 123.—Right unciform of *Dinoceras mirabile*, Marsh (No. 1211); side view.
Figure 124.—Right unciform of *Tinoceras ingens*, Marsh (No. 1509); side view.
*mc*V. face for fifth metacarpal; *p*. face for pyramidal.
Both figures are one-half natural size.

Four specimens of the unciform bone from different individuals of *Dinocerata* have the following dimensions:

Measurements of Left Unciform. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of longitudinal axes of unciform,	.041–.068
Antero-posterior diameter,	.068
Transverse diameter,	.086
Antero-posterior diameter of lunar articular face,	.062
Transverse diameters of lunar articular face,	.020–.024
Antero-posterior diameter of face for pyramidal,	.060
Transverse diameter of face for pyramidal,	.055
Antero-posterior diameter of face for third metacarpal,	.050
Transverse diameter of face for third metacarpal,	.025
Antero-posterior diameter of face for fourth metacarpal,	.056
Transverse diameters of face for fourth metacarpal,	.021–.043
Antero-posterior diameter of face for fifth metacarpal,	.048
Transverse diameters of face for fifth metacarpal,	.020–.025

Measurements of Right Unciform. (*Dinoceras mirabile*, No. 1195.)

	m.
Length of longitudinal axes of unciform,	.038–.065
Antero-posterior diameter,	.067
Transverse diameter,	.079
Antero-posterior diameter of face for lunar,	.059
Transverse diameter of face for lunar,	.019
Antero-posterior diameter of face for pyramidal,	.061
Transverse diameter of face for pyramidal,	.068
Antero-posterior diameter of face for third metacarpal (approximate),	.052
Transverse diameter of face for third metacarpal,	.026

	m.
Antero-posterior diameter of face for fourth metacarpal,	.055
Transverse diameters of face for fourth metacarpal,	.013–.044
Antero-posterior diameter of face for fifth metacarpal,	.041
Transverse diameter of face for fifth metacarpal,	.023

Measurements of Right Unciform. (*Dinoceras mirabile*, No. 1247.)

	m.
Length of longitudinal axes of unciform,	.046–.073
Antero-posterior diameter,	.084
Transverse diameter,	.091
Antero-posterior diameter of face for lunar,	.070
Transverse diameter of face for lunar,	.023
Antero-posterior diameter of face for pyramidal,	.073
Transverse diameter of face for pyramidal,	.083
Antero-posterior diameter of face for third metacarpal (approximate),	.057
Transverse diameter of face for third metacarpal,	.029
Antero-posterior diameter of face for fourth metacarpal,	.070
Transverse diameters of face for fourth metacarpal,	.019–.048
Antero-posterior diameter of face for fifth metacarpal,	.055
Transverse diameter of face for fifth metacarpal,	.025

Measurements of Right Unciform. (*Tinoceras ingens*, No. 1509.)

	m.
Length of longitudinal axes of unciform (approximate),	.051–.085
Antero-posterior diameter,	.080
Tranverse diameter,	.098
Antero-posterior diameter of face for pyramidal (approximate),	.070
Transverse diameter of face for pyramidal,	.077
Antero-posterior diameter of face for third metacarpal,	.057
Transverse diameter of face for third metacarpal,	.027
Antero-posterior diameter of face for fourth metacarpal,	.067
Transverse diameters of face for fourth metacarpal,	.016–.055
Antero-posterior diameter of face for fifth metacarpal,	.056
Transverse diameter of face for fifth metacarpal,	.030

The Metacarpal Bones.

(Plates XXXV, XXXVI, XXXVII, and Plate LIV, figure 1.)

The metacarpal bones in the *Dinocerata* are short and robust. They are five in number, and each represents a well developed digit. Their general form and position in the foot of *Dinoceras mirabile* are shown in Plate LIV, figure 1, and also in the restoration of this species, Plate LV.

The First Metacarpal. (Plate XXXV, figures 1–6.)

The metacarpal bone of the first, or inner, digit, the pollex, is a robust, and usually short bone, proportionally much stronger than in the elephant. In all the specimens preserved, the epiphyses, whether present on one end only, or on both ends, as in the elephant, are firmly coössified with the shaft of the bone. The surface of the bone, as shown in Plate XXXV, figures 1–4, is rough and very irregular.

The proximal articular face (figure 5) is nearly elliptical in outline, and is flattened, but elevated, near the middle of the palmar side of the margin. On some specimens, there is a distinct oval face for contact with the second metacarpal. This face is raised upon a large tubercular elevation, and may, or may not, be in contact with the proximal articular face.

The distal end (figure 6) presents a flattened, and somewhat concave, face for the phalangeal bone, and two broad, oblique grooves for the sesamoids.

Three first metacarpals of *Dinoceras* have their principal dimensions as follows:

Measurements of First Metacarpal. (*Dinoceras mirabile*, No. 1208.)

	m.
Total length of first metacarpal,	.063
Diameters of proximal articular face (approximate),	.025–.044
Diameters of face for phalanx,	.027–.034

Measurements of First Metacarpal. (*Dinoceras mirabile*, No. 1211.)

	m.
Total length of first metacarpal,	.098
Diameters of proximal articular face (approximate),	.030–.050
Diameters of face for phalanx,	.037–.043
Diameters of face for second metacarpal,	.020–.022

Measurements of First Metacarpal. (*Dinoceras*, No. 1526.)

	m.
Total length of first metacarpal,	.056
Diameters of proximal articular face (approximate),	.026–.044
Diameter of face for phalanx,	.030

THE SECOND METACARPAL. (Plate XXXV, figures 7–12.)

The metacarpal supporting the second digit in the *Dinocerata* is nearly twice as long as the first, but not greatly wider, nor thicker. The shaft is strongly roughened and tuberculated near each end, as shown in Plate XXXV, figures 7–10, while the middle portion is much smoother.

The proximal end of the bone presents three distinct, but confluent, articular faces, of which the first, beginning on the radial side, is the largest. It met the trapezoid, and furnished the principal support of that bone. This face, shown in figure 11, is oblique to the axis of the bone, throwing it, in its natural position, well toward the radial side of the manus. It is a little broader, and more oblique, above than below, and is slightly concave in both directions.

A second adjoining face, shorter and smaller, shown also in figure 11, is nearly perpendicular to the axis of the bone, slightly narrowed behind, and convex in both directions. In life, this face articulated with the oblique distal face of the magnum.

A third face, on the ulnar side of the bone at the proximal end, shown best in figure 10, articulated with a similar face on the adjoining third metacarpal.

The distal end of the bone (figure 12) bears a broadly oval, only slightly convex, articular face for the phalanx. This is encroached upon below, by the broad, shallow grooves for sesamoid bones.

The principal dimensions of the second metacarpal represented in Plate XXXV are as follows:

Measurements of Second Metacarpal. (*Dinoceras mirabile*, No. 1208.)

	m.
Total length of second metacarpal,	.102
Diameters of proximal end,	.039–.065
Diameters of distal end,	.046–.058
Diameters of shaft,	.030–.040
Antero-posterior diameter of face for trapezoid,	.050
Transverse diameters of face for trapezoid,	.020–.023
Antero-posterior diameter of face for magnum,	.046
Transverse diameters of face for magnum,	.012–.018
Antero-posterior diameter of face for third metacarpal,	.040
Diameters of face for phalanx,	.025–.041

The Third Metacarpal. (Plate XXXVI, figures 1–6.)

The third metacarpal resembles the second in general size and shape, but may be readily distinguished from it by the presence, on the proximal end, of four, instead of three, articular faces. Like that bone, it is rough and tuberculated, especially near the ends. It bears, also, a rugose surface not far above the middle of its shaft on the ulnar side, best shown in Plate XXXVI, figures 1 and 3.

Of the four proximal articular faces, the first, beginning on the radial side is almost entirely on the lateral surface of the bone, as represented in figure 2. In life, it moved upon a corresponding face on the adjoining second metacarpal. It is confluent, along its proximal margin, with the second articular face, which is the largest of the four, and articulated with the principal distal face of the magnum.

This face, shown in figures 2 and 5, extends with parallel sides across the proximal end of the bone, from before backward. It is concave from side to side, though slightly convex antero-posteriorly, and formed, during life, the principal support of the bone. Its plane is more inclined to the axis of the bone than is that of the third face, which, in life, rested on the unciform.

The third face, best shown in figure 5, is large and triangular, the apex of the triangle being turned posteriorly, or toward the palmar surface of the manus. This face articulated with the unciform. It is convex in both directions, and, being more nearly perpendicular to the axis of the metacarpal than is the face for the magnum, must have contributed, during life, nearly as much to its support.

The face for the unciform is confluent along its entire outer, or ulnar, margin with a fourth, broad articular face on the side of the bone (figure 4), which, in life, met a corresponding face on the fourth metacarpal.

The distal end of the bone (figure 6) supports a moderately convex face for the phalangeal articulation, placed well upon the upper surface of the bone, and scarcely extending as low as the middle of the distal end. Here, it is met by the broad and shallow grooves, in which a pair of

sesamoid bones moved during life. The ridge between these grooves is nearly obsolete in front, but well developed posteriorly.

The more important measurements of two third metacarpals of *Dinoceras* are given below.

Measurements of Third Metacarpal. (*Dinoceras mirabile*, No. 1208.)

	m.
Total length of third metacarpal,	.114
Diameters of proximal end,	.052–.062
Diameters of distal end,	.044–.054
Diameters of shaft,	.031–.042
Antero-posterior diameter of face for second metacarpal,	.040
Transverse diameter of face for second metacarpal,	.015
Antero-posterior diameter of face for magnum,	.056
Transverse diameter of face for magnum,	.022
Antero-posterior diameter of face for unciform,	.050
Transverse diameter of face for unciform,	.030
Antero-posterior diameter of face for fourth metacarpal,	.050
Transverse diameter of face for fourth metacarpal,	.025
Diameters of face for phalanx,	.025–.042

Measurements of Third Metacarpal. (*Dinoceras mirabile*, No. 1529.)

	m.
Diameters of proximal end of third metacarpal,	.044–.073
Diameters of shaft,	.032–.040
Antero-posterior diameter of face for second metacarpal,	.043
Transverse diameter of face for second metacarpal,	.014
Antero-posterior diameter of face for magnum,	.069
Transverse diameter of face for magnum,	.025
Antero-posterior diameter of face for unciform (approximate),	.055
Transverse diameter of face for unciform,	.030
Antero-posterior diameter of face for fourth metacarpal,	.059
Transverse diameter of face for fourth metacarpal,	.015–.018

The Fourth Metacarpal.

(Plate XXXVI, figures 7–9, and Plate XXXVII, figures 1–3.)

The fourth metacarpal in the *Dinocerata* is a robust bone, like the second and third of the series. It may be easily distinguished by the broad, sub-triangular, convex articular face, at right angles with the axis of the bone, and covering its entire proximal end.

The surface of the bone is roughened towards the ends, but smoother along the shaft, as shown in Plate XXXVI, figures 7 and 8, and Plate XXXVII, figures 1 and 2. It is considerably extended antero-posteriorly near the proximal end, but is constricted at the middle.

The proximal end (Plate XXXVII, figure 3) is almost completely covered by the articular face for the unciform bone, by which the fourth metacarpal was entirely supported. This face is convex in both directions, and broad in front. It becomes much narrower behind, or toward the palmar side of the manus, so as to appear triangular, but does not come quite to a point. Along each side, it is confluent with narrow faces, nearly at right angles with the main surface, which joined, during life, corresponding faces on the third and fifth metacarpals.

The largest of these lateral faces, shown in Plate XXXVI, figure 8, extends along the entire margin of the unciform face on its radial side, and was adapted to the third metacarpal.

On the opposite, or ulnar, side (Plate XXXVII, figure 2), a smaller and shorter face, sometimes, as in the specimen figured, much larger anteriorly, was adapted, during life, to the fifth metacarpal.

The distal end of the bone (Plate XXXVI, figure 9) presents a rounded, and but slightly convex, face for the phalanx, and below are shallow grooves for the two sesamoid bones.

Measurements of the fourth metacarpal bone in four specimens of the *Dinocerata* are as follows:

Measurements of Fourth Metacarpal. (*Dinoceras mirabile*, No. 1211.)

	m.
Total length of fourth metacarpal,	.131
Diameters of proximal end,	.050–.081
Diameters of distal end,	.052–.044
Diameters of shaft (approximate),	.038–.041
Antero-posterior diameter of face for unciform,	.076
Transverse diameters of face for unciform,	.022–.048
Antero-posterior diameter of face for third metacarpal,	.062
Transverse diameters of face for third metacarpal,	.013–.022
Antero-posterior diameter of face for fifth metacarpal,	.052
Transverse diameters of face for fifth metacarpal,	.060–.022
Diameters of face for phalanx,	.035–.040

Measurements of Fourth Metacarpal. (*Dinoceras lucare*, No. 1038.)

	m.
Total length of fourth metacarpal,	.117
Diameters of proximal end,	.047–.064
Diameters of distal end,	.054–.041
Diameters of shaft (approximate),	.027–.039
Antero-posterior diameter of articular face for unciform (approximate),	.060
Transverse diameters of articular face for unciform (approximate),	.021–.040
Antero-posterior diameter of articular face for third metacarpal (approximate),	.050
Transverse diameters of articular face for third metacarpal (approximate),	.012–.020
Antero-posterior diameter of articular face for fifth metacarpal,	.042
Transverse diameters of articular face for fifth metacarpal (approximate),	.080–.018
Diameters of articular face for phalanx,	.032–.042

Measurements of Fourth Metacarpal. (*Dinoceras*, No. 1523.)

	m.
Total length of fourth metacarpal,	.096
Diameters of proximal end (approximate),	.040–.061
Diameters of distal end,	.045–.034
Diameters of shaft (approximate),	.020–.033
Antero-posterior diameter of articular face for unciform,	.058
Transverse diameter of articular face for unciform,	.040
Antero-posterior diameter of articular face for fifth metacarpal,	.042
Transverse diameters of articular face for fifth metacarpal,	.040–.017
Diameters of articular face for phalanx,	.023–.039

Measurements of Fourth Metacarpal. (*Tinoceras ingens*, No. 1219.)

	m.
Total length of fourth metacarpal,	.117
Diameters of proximal end,	.054–.071
Diameters of shaft (approximate),	.028–.040
Antero-posterior diameter of articular face for unciform,	.064
Transverse diameter of articular face for unciform (approximate),	.048
Antero-posterior diameter of articular face for third metacarpal,	.055
Transverse diameters of articular face for third metacarpal,	.014–.019
Antero-posterior diameter of articular face for fifth metacarpal,	.047
Transverse diameter of articular face for fifth metacarpal,	.020
Diameters of articular face for phalanx,	.030–.042

The Fifth Metacarpal. (Plate XXXVII, figures 4–9.)

The specimens of the fifth metacarpal in the Yale Museum are, unfortunately, all more or less distorted by pressure, and hence fail to fully represent this element of the manus. The bone is well developed, scarcely smaller than the third and fourth, and considerably surpasses the first in length. Like the other bones of the metacarpal series, it is rough and tubercular, especially toward the ends.

The proximal end (Plate XXXVII, figure 8) presents three articular faces, of which the main and middle one, for the support of the bone upon the unciform, is strongly convex. The convexity is carried through a considerable arc in the antero-posterior direction, to correspond with the outer, and most concave facet, on the unciform bone, to which it is adapted. This surface is bordered, on the inner, or radial side, by a face, broadest anteriorly, for motion on the fourth metacarpal. Behind, and on the outer, or ulnar, side of the principal articular face, is a much smaller face, which, in life, moved upon a corresponding articulation on the distal end of the pyramidal.

In some specimens, the shape of the unciform, as shown on page 119, figure 124, would seem to make this impossible, and doubtless this face will not be found to be constantly present on the fifth metacarpal.

The distal end of the bone (Plate XXXVII, figure 9) presents, as usual, a round, or oval, face for articulation with the phalanx, and shallow grooves below for a pair of sesamoids.

The specimens preserved are so much distorted that measurements would be of comparatively little value.

The Phalanges. (Plate XXXVIII, and Plate LIV, figure 1.)

The phalanges in the fore foot of the *Dinocerata* are very short, and comparatively small. Their general characters are shown in the Plates cited above, as well as in the restorations given in Plates LV and LVI.

The proximal phalanges (Plate XXXVIII, figures 1 and 2) are much the largest. The proximal surface has no central groove, and is adapted to the comparatively smooth face on the distal end of the metacarpals.

The median phalanges (figures 3 and 4) are much shorter than those described above. Their proximal articular faces are nearly flat, and the distal ones, smaller, and more concave transversely.

The ungual phalanges (figures 5 and 6) are larger than those of the median series, and, with the exception of the small articular face, their surfaces are very rugose.

CHAPTER IX.

THE RIBS AND STERNUM.

(Plates XXXIX, XL, LV, and LVI.)

The ribs in the *Dinocerata* present no special characters of importance. Their general features are well shown in the illustrations above cited, especially in the restorations at the end of the volume.

The First Rib.

(Plate XXXIX, figures 1–3.)

The first rib in the *Dinocerata* has a general resemblance to the corresponding bone in the mastodon. It is, however, proportionally shorter, and more flattened at the sternal end.

This rib presents a well rounded articular face to the first dorsal vertebra, and, confluent with this, on the anterior side of the head, is another strongly convex face, for articulation with a well developed facet near the posterior margin of the last cervical vertebra.

The tubercular articulation is but little elevated above the capitular. It is convex from before backward, concave from side to side, and looks almost perpendicularly upward, being directed but very slightly backward. The tubercle of the rib extends outward beyond the articular face.

The shaft is moderately roughened, more especially on its anterior, or outer, surface. The sternal face is so strongly flattened and expanded that the external border of the rib shows only a very moderate degree of curvature. The inner border, however, is strongly curved, mostly in the upper half of the bone.

THE ANTERIOR DORSAL RIBS. (Woodcuts 125–132, below.)

The second rib in one species of *Uintatherium* is represented in the figures below.

FIG. 125.

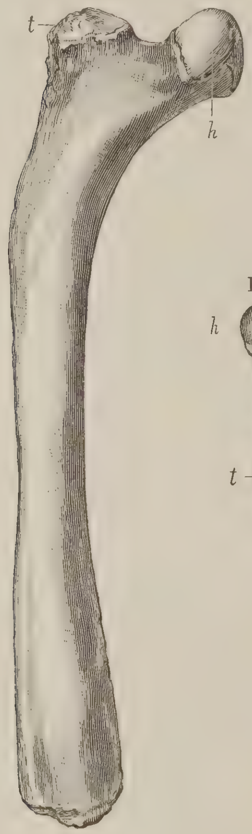


FIG. 126.

FIG. 127.

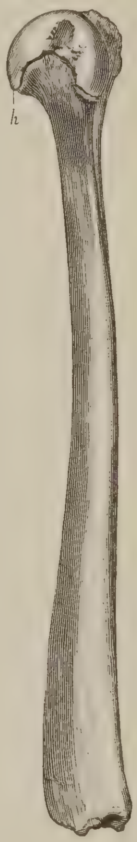


FIG. 128.

FIGURE 125.—Second rib of *Uintatherium latifrons*, Marsh (No. 1231); posterior view.
FIGURE 126.—The same rib; front view.
FIGURE 127.—The same rib; inner view.
FIGURE 128.—The same rib; proximal end.
h. head; *t.* tubercle.

All the figures are one-fourth natural size.

The second rib is much longer, and less robust, than the first, above described. The head is large, and the two articular faces on it are confluent. The tubercle is well developed, and at nearly the same level as the head. The shaft is only moderately curved, and considerably compressed. The distal end is flattened, and wider than the shaft.

The ribs behind the second gradually increase in length, and become more curved. The head remains large, and its articular faces are usually separated from each other, as shown in figures 129–132, below.

FIG. 129. FIG. 130. FIG. 131.

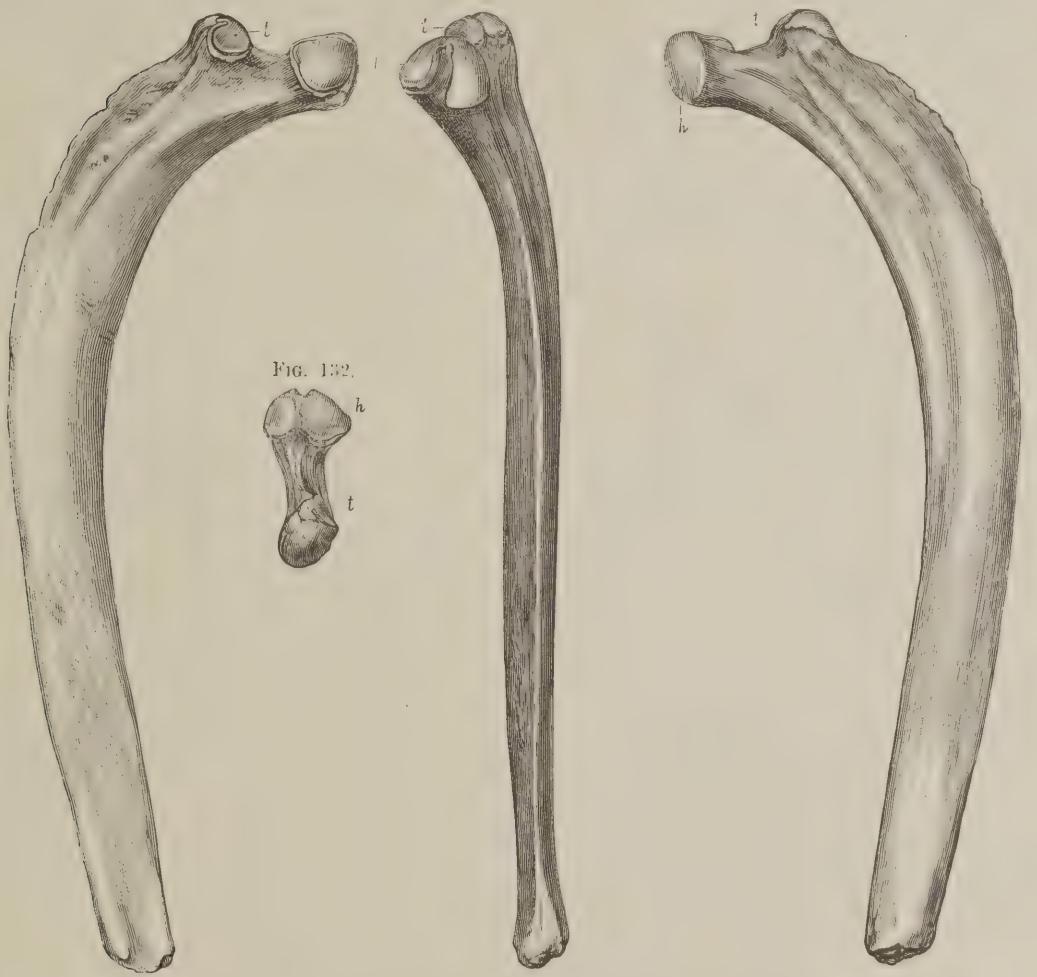


FIGURE 129.—Anterior rib of *Dinoceras mirabile*, Marsh (No. 1212); posterior view.
FIGURE 130.—The same rib; inner view.
FIGURE 131.—The same rib; front view.
FIGURE 132.—The same rib; proximal end.
h. head; *t*. tubercle.

All the figures are one-fourth natural size.

The main dimensions of the first rib in one individual of *Dinoceras mirabile* are as follows:

Measurements of First Rib. (*Dinoceras mirabile*, No. 1251.)

	m.
Total length of rib,	.320
Greatest diameter of head,	.038
Transverse diameter of head,	.032
Diameters of tubercular articulation,	.020–.030
Diameters of shaft, near the middle,	.021–.040
Diameters of shaft, at sternal end,	.027–.095

The principal measurements of the second rib of *Uintatherium* are given below.

Measurements of Second Rib. (*Uintatherium latifrons*, No. 1231.)

	m.
Total length of rib, in straight line,	.440
Greatest diameter of head,	.055
Transverse diameter of head,	.030
Diameter of tubercular articular face,	.024
Diameters of shaft, near the middle,	.020–.039
Diameters of shaft, at lower end (approximate),	.025–.060

The dimensions of two dorsal ribs of *Dinoceras* are as follows:

Measurements of Anterior Rib. (*Dinoceras mirabile*, No. 1212.)

	m.
Total length of rib, in straight line,	.500
Greatest diameter of head,	.048
Transverse diameter of head,	.036
Diameter of tubercular articular face (approximate),	.023
Diameters of shaft, near the middle,	.022–.060
Diameters of shaft, at lower end (approximate),	.025–.038

Measurements of Median Rib. (*Dinoceras mirabile*, No. 1210.)

	m.
Total length of rib, in a straight line,	.605
Diameters of head,	.047–.058–.065
Diameters of neck,	.034–.039
Diameters of shaft,	.017–.057

THE POSTERIOR RIBS. (Plate XXXIX, figures 4–9.)

The posterior ribs gradually diminish in length, and become more slender, but the curvature is still strongly marked. In most of them, the head is large, and the two articular faces on it, distinct. The tubercle diminishes in size, and toward the last is a mere sessile articular face.

The sternal ribs are not preserved in any of the known specimens of the *Dinocerata*, and they were probably unossified. Their general form and position are indicated in the restorations, Plates LV and LVI.

The more important dimensions of two posterior ribs in the type of *Dinoceras mirabile* are the following:

Measurements of Dorsal Rib. (*Dinoceras mirabile*, No. 1036.)

	m.
Total length of rib, in straight line,	.530
Greatest diameter of head,	.052
Transverse diameter of head,	.037
Least diameter of shaft, near the middle,	.015
Diameters of shaft, at broadest point,	.025–.060

Measurements of Posterior Rib. (*Dinoceras mirabile*, No. 1036.)

	m.
Total length of rib, in straight line,	.520
Greatest diameter of head,	.056
Transverse diameter of head,	.062
Diameters of shaft, at broadest point,	.016–.051

THE STERNUM.

(Plate XL; and woodcut 133, below.)

Sternal bones are preserved in a number of individuals of the *Dinocerata* in the Yale Museum, but the entire series in any one individual has not been recovered. The general form and character of these bones are shown in the figures, Plate XL. A series in the natural position is represented in the woodcut below.

The most marked character of these bones in the *Dinocerata* is that they are flat and horizontal, as in the Artiodactyls, and not vertical, as in the Proboscidians, and the Perissodactyls. The first bone of the series, or the pre-sternum, is compressed, pointed in front, and, at this end, has two distinct facets for the first pair of ribs. This bone is shown in Plate XL, figures 1, 2, and 3.

The bones which follow, and compose the meso-sternum, are broad and flat, somewhat constricted near the middle, with the ends more or less convex. The anterior ends are usually strongly convex, while the posterior extremities may be nearly flat.

Two examples of these median sternal bones are shown in the same Plate, figures 4–9, as well as in the woodcut below.

FIG. 133.

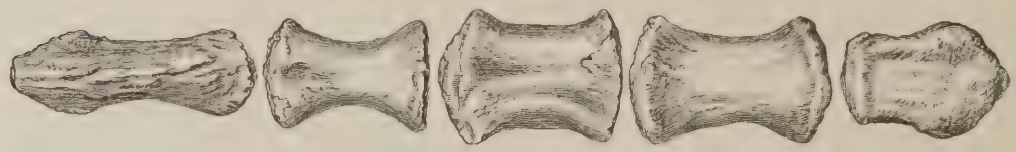


FIGURE 133.—Sternum of *Dinoceras mirabile*, Marsh; top view.
One-fifth natural size.

The last sternal bone of the series, or the xiphi-sternum, is also broad and flat, but has the posterior extremity pointed. This bone is shown in figures 10–12, of the same Plate.

The surface of all the sternal bones is quite rugose, and the extremities are deeply pitted for union with the cartilage that held them in position.

No indication of clavicles has been observed.

CHAPTER X.

THE PELVIC ARCH AND TAIL.

(Plates XLI, XLII, XLIII, LV, and LVI.)

The Pelvis.

(Plates XLI–XLII; and woodcuts 134–135, below.)

In all the known specimens of the *Dinocerata* in which the pelvic arch is preserved, the ilium, ischium, and pubis are firmly coösified with each other, but not with the sacrum. The three pelvic bones on each side unite with each other earlier, and much more closely, than they do with the sacrum above, or with the opposite pelvic bones below. The sutures for the latter union remained open until the animal was fully adult, and, even then in some specimens, were readily separated. These features are well shown in Plate XLI.

The pelvis of *Dinoceras* may be compared with that of the elephant, to which it bears a considerable resemblance, but from which it differs in many important particulars.

The ilia are much expanded, and nearly quadrant-shaped in outline, the supra-iliac border being very regularly curved, and only moderately thickened near its union with the acetabular border, which it joins at about a right angle. The iliac surface is moderately concave in both directions, especially near the surface for union with the sacrum.

The gluteal surface is nearly flat where most expanded, but becomes convex in the acetabular region. It rises but little above the sacral articular surface, which is short, somewhat triangular in outline, and

presents a strong union with the transverse processes of the first two sacral vertebræ.

The ilia are more rounded in outline, and the pubes are less firmly united at the symphysis, than in the mastodon. The ischia, also, do not unite at all, as in that animal, but are rounded off, and distant from each other.

FIG. 134.

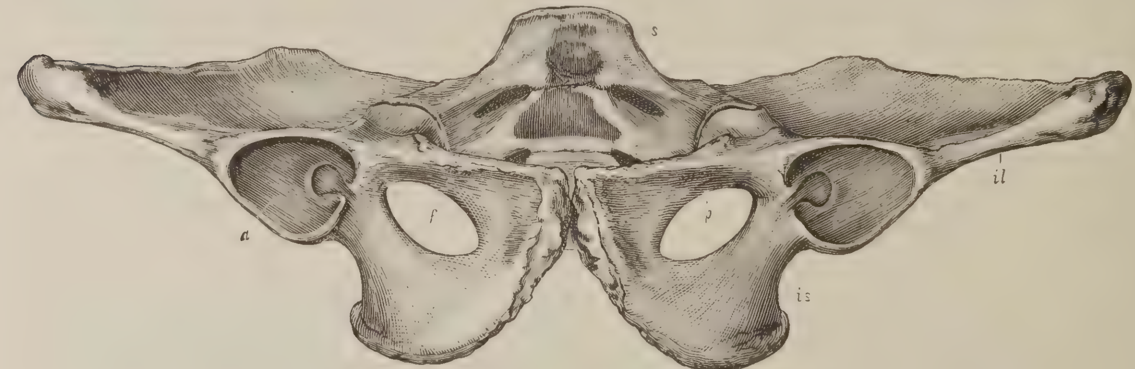


FIGURE 134.—Pelvis of *Tinoceras ingens*, Marsh (No. 1497); seen from below.

FIG 135.

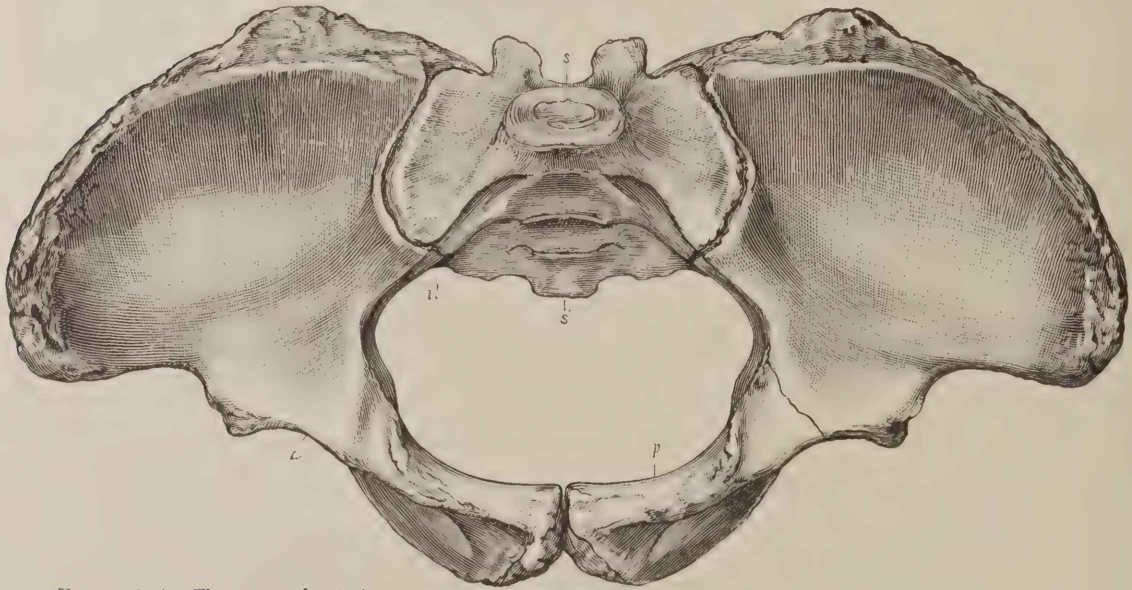


FIGURE 135.—The same; front view

a. acetabulum; *f.* thyroid foramen; *il.* ilium; *is.* ischium; *p.* pubis; *s.* anterior end of sacrum; *s'.* posterior end of sacrum.

Both figures are one-eighth natural size.

The pelvic arch in *Tinoceras* is similar, in its general features, to that of *Dinoceras*, but presents various differences which are apparent in comparing the figures 134 and 135, above, with the corresponding views of the type specimen of *Dinoceras mirabile* represented in Plate XLI.

The sacrum in *Dinoceras* differs from that of *Mastodon Americanus* in having four sacral vertebræ instead of five, and much larger transverse processes, for articulation with the ilia. The foramina between these processes are also proportionally much larger. Only the first two of the processes unite strongly with the ilium, instead of four, as in the mastodon. Both the sacrum, and the face for attachment to the ilium, are proportionally much shorter than in the mastodon.

The more important dimensions of the pelvic arch in the type specimen of *Dinoceras mirabile*, and in one individual of *Tinoceras ingens*, are the following:

Measurements of Pelvis. (*Dinoceras mirable*, No. 1036.)

	m.
Greatest transverse diameter, across ilia,	1.120
Horizontal diameter of pelvic opening (approximate),	.350
Vertical diameter of pelvic opening (approximate),	.250
Diameter across acetabula,	.660
Diameters of acetabulum,	.110–.125
Diameters of thyroid foramen,	.075–.150
Length of symphysis pubis,	.140
Length of four sacral vertebræ (approximate),	.245
Extent of transverse processes of first sacral,	.330
Horizontal diameter of anterior face of first sacral,	.110
Vertical diameter of anterior face of first sacral,	.075
Length of first sacral centrum,	.075

Measurements of Pelvis. (*Tinoceras ingens*, No. 1497.)

	m.
Greatest transverse diameter, across ilia,	1.180
Horizontal diameter of pelvic opening (approximate),	.400
Vertical diameter of pelvic opening (approximate),	.300
Diameter across acetabula,	.700
Diameters of thyroid foramen,	.060–.150
Length of symphysis pubis,	.140
Length of four sacral vertebræ,	.295
Extent of transverse processes of first sacral,	.355
Horizontal diameter of anterior face of first sacral,	.117

	m.
Vertical diameter of anterior face of first sacral,	.072
Length of centrum of first sacral,	.085
Length of centrum of second sacral,	.075
Length of centrum of third sacral,	.065
Length of centrum of fourth sacral,	.067

The Caudal Vertebræ.

(Plate XLIII; and woodcut 136, below.)

The anterior caudal vertebræ of the *Dinocerata* have the centra short and flat, with long and depressed transverse processes. The neural spine is only moderately developed. The neural arch is low, and situated on the anterior two-thirds of the centra. The zygapophyses are weak, and their articular faces usually curved.

In the median caudals, the transverse processes become shorter, and gradually disappear.

The distal caudals are cylindrical, and of moderate length. They are without zygapophyses, or neural arches, as seen in figure 136, below.

Fig. 136.

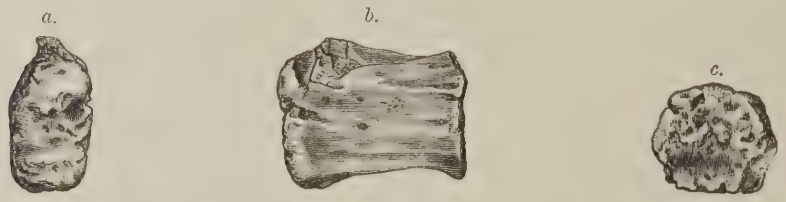


Figure 136.—Caudal vertebra of *Dinoceras laticeps*, Marsh (No. 1039).
a. proximal end; *b*. side view; *c*. distal end.
All the figures are one-half natural size.

The under surface of the caudal vertebræ is rugose, and there are no chevron bones.

CHAPTER XI.

THE HIND LIMBS.

(Plates XLIV, XLV, XLVI, LV, and LVI.)

The hind limbs of the *Dinocerata* have a general resemblance to those of Proboscidians, but the bones composing them are comparatively shorter, and more robust. When the animal was standing at rest, the posterior limb formed a strong and nearly vertical column. The contrast in this respect between the hind and the fore limb has already been stated, in the description of the latter in Chapter VII.

The Femur. (Plate XLIV; and woodcuts 137–138, below.)

The femur in the *Dinocerata* is proportionally shorter than in the elephant. It is much smoother throughout than the humerus, and is also somewhat longer than that bone.

The head of the femur is hemispherical, and its axis makes an angle of about fifteen degrees with the axis of the shaft of the bone. The diameter of the head is contained about five and one-half times in the length of the femur. There is no indication of any pit for the round

ligament, as is seen in Plate XLIV, figure 3 *a*. The great trochanter scarcely rises above the base of the head. It is flattened, and posteriorly is excavated below.

The upper end of the shaft is broad, flattened in a fore and aft direction, and is excavated behind, especially below the great trochanter. It contracts in transverse diameter gradually to a minimum, near the middle of the shaft, and just below the trochanter minor, where it is flattened behind, but strongly rounded in front. Below this point, it becomes flat behind, and, lower still, is excavated, while the anterior surface is rounded throughout. The anterior and posterior surfaces of the bone, along the inner side, pass into each other by gradual curvature, except in the region of the trochanter minor. The latter process is less than one-third of the way down the shaft, and somewhat stronger than in the elephant. There is no third trochanter.

The curved front surface of the femur is separated from the flattened posterior face by a rounded ridge, extending along the outer and posterior sides nearly the entire length of the shaft. This ridge sharply separates the two faces, but nowhere rises conspicuously above the general surface of the bone, and disappears near the proximal end. Near the distal end, the surface is roughened, but is destitute of the conspicuous fossa above the outer condyle, seen in the horse and the hippopotamus.

The condyles resemble those of the elephant, and, as in that animal, are so placed upon the end of the shaft as to permit the knee-joint to be straightened when standing at rest, and in walking. The characteristic elephantine gait must, therefore, have been assumed by the *Dinocerata*.

The inner condyle is a little greater than the outer in transverse diameter, but much less in antero-posterior dimensions. The two are separated from each other by a deep narrow sulcus, but both are completely confluent above with the shallow and short groove for the patella. This groove is broadly rounded from side to side, and less distinctly pulley-shaped, than in the elephant. It is near the middle of the anterior surface of the bone, and does not rise above the general surface, except to a very small extent along its lateral margins, which are acute, and sub-equal in height.

There is no medullary cavity in the femur, the inner texture of the shaft being merely somewhat cancellated, as shown in the woodcuts below.

FIG. 137.

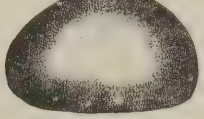


FIG. 138.

FIGURE 137.—Section of femur of *Dinoceras mirabile*, Marsh (No. 1206).
FIGURE 138.—Section of same bone (No. 1210).
Both figures are one-fourth natural size.

The main dimensions of the femur in one specimen of *Dinoceras* are given below.

Measurements of Right Femur. (*Dinoceras mirabile*, No. 1206.)

	m.
Length of femur,	.690
Diameters of head,	.123–.126
Distance from summit of head to trochanter minor,	.200
Height of trochanter minor,	.015
Transverse diameter through great trochanter,	.215
Least diameters of shaft,	.067–.093
Transverse diameter of distal end,	.170
Greatest antero-posterior diameter of distal end,	.160
Least antero-posterior diameter of distal end,	.100
Transverse diameter of inner condyle,	.065
Transverse diameter of outer condyle,	.070

THE TIBIA. (Plate XLV.)

The tibia in the *Dinocerata* is much shorter than the femur, as in the elephant and the mastodon, and considerably resembles the same bone in these animals. It differs noticeably in the greater prominence of the tuberosity for the attachment of the patellar ligament.

The proximal articular surfaces for the condyles of the femur are confluent, or very nearly so, being separated by only a low, smooth and rounded ridge, as seen in Plate XLV, figure 3 *a*. The inner face is larger in antero-posterior diameter than the outer, and is concave

throughout in both directions, except for a very small area near its posterior margin. The outer face is shorter, but much broader than the inner, and posteriorly is much more convex, and thus adapted, in extreme flexion of the leg, to a concave face on the outer condyle of the femur. These faces may indicate the presence of a flabella.

Below the outer and posterior part of this articular surface, is a small flattened facet, looking nearly downward, and somewhat outward and backward, for articulation with the fibula.

The upper end of the shaft presents in front a deep rounded excavation, bounded at the sides and below by a roughened curved ridge for muscular attachment. The shaft is contracted in the middle, but expands below, and has its distal end nearly covered by the broad surface for articulation with the astragalus.

This articular face is confluent along its outer margin with a small oblique face for the distal end of the fibula. It is concave antero-posteriorly, but, in transverse section across the middle, is at first slightly convex on the internal malleolus, then concave, and again moderately convex to the margin of the fibular articulation. This face is represented in Plate XLV, figure 1 *a*.

The tibia is nearly, or quite, solid, as shown in figure 5 of the same Plate.

Measurements of Tibia. (*Dinoceras mirabile*, No. 1208.)

	m.
Total length of tibia,	.390
Greatest diameter, proximal end,	.140
Antero-posterior diameter, below patella,	.096
Antero-posterior diameter of inner proximal articular surface,	.080
Transverse diameter of inner proximal articular surface,	.062
Antero-posterior diameter of outer proximal articular surface,	.070
Transverse diameter of outer proximal articular surface,	.075
Greatest diameter of fibular articular surface,	.033
Least diameter of fibular articular surface,	.027
Least diameters of shaft,	.052–.057
Greatest diameter, distal end,	.107
Antero-posterior diameter, distal end,	.093
Greatest diameter of astragalar surface (approximate),	.095
Antero-posterior diameters of astragalar surface,	.067–.080
Antero-posterior diameter of distal fibular surface,	.035
Least diameter of distal fibular surface,	.015

The Fibula. (Plate XLVI, figures 1–4.)

The fibula is slender, and entire, with articular faces well marked at each extremity. The proximal end is somewhat expanded, and has the articular face for union with the tibia oblique, and sub-oval in outline. The shaft is somewhat twisted, and sub-triangular in transverse section. The distal end of the fibula is larger than that above, and quite rugose. The articulation for union with the astragalus is large, and placed obliquely, as shown in Plate XLVI, figure 4.

In some specimens of the *Dinocerata*, and probably in all, the fibula met the calcaneum, as in *Coryphodon*, and the Artiodactyls.

Measurements of the fibula in two individuals of *Dinoceras* are as follows:

Measurements of Fibula. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of fibula (approximate),	.350
Diameters of proximal end,	.040–.045
Diameters of proximal articular surface,	.028–.033

Measurements of Fibula. (*Dinoceras mirabile*, No. 1210.)

	m.
Diameters of shaft,	.028–.020
Diameters of distal end,	.040–.070
Diameters of distal articular surface (approximate),	.050–.045

The Patella. (Plate XLVI, figures 5–8.)

The patella in the *Dinocerata* is a large bone, and resembles, in its general features, that of the elephant. Its external surface is quite rugose. The articular surface for union with the condyles of the femur is sub-oval in outline, concave from above downward, and transversely convex in consequence of the usual median swelling. The general characteristics are well represented in Plate XLVI, and its position in the skeleton is shown in the restorations at the end of the volume, Plates LV and LVI.

CHAPTER XII.

THE HIND LIMBS. (Continued.)

(Plates XLVII–LVI.)

The hind feet in the *Dinocerata* were considerably smaller than those in front. Their component parts are short and robust, forming together a strong support for the massive hind limbs. There were five digits, as in the Proboscidians, and the axis of the foot was through the third, or middle, digit.

The general appearance of the hind foot in *Dinoceras mirabile* is represented in Plate LIV, figure 2. The fore foot, or manus, is seen in figure 1 of the same Plate, and both feet are shown in different positions in the restorations, Plates LV and LVI.

The Tarsal Bones.

(Plates XLVII–L, Plate LIV, figure 2; and woodcuts 139–146, below.)

There are seven well developed tarsal bones in the *Dinocerata*, and their relative position in the hind foot is seen in Plate LIV. These bones are described in detail below. An eighth tarsal bone, the tibiale, appears to have been present.

The Astragalus.

(Plate XLVII, Plate LIV, figure 2, *a*; and woodcuts 139–142, below.)

The astragalus in the *Dinocerata* considerably resembles that of the elephant, the bone being, as in that animal, very short, along the axis of the leg and foot. The articular faces are, moreover, but little curved, indicating comparatively slight freedom of motion in the ankle joint.

The superior, or proximal, face of the bone, articulating with the tibia, is shown in Plate XLVII, figure 1. This surface is sub-quadrate in general outline, with rounded angles, but is prolonged posteriorly on the inner, or tibial, side into a large convex lobe.

The surface of the tibial articulation is moderately convex from before backward, and, in front, nearly flat from side to side, but, posteriorly, it becomes somewhat excavated, this being the only indication of the conspicuous groove common in Ungulates. The tibial articular surface is confluent, along the posterior part of its outer margin, with a somewhat convex, rounded face for the fibula, as shown in figure 4.

The inner surface of the bone (figure 2), or that which is presented upon the tibial side of the foot, is excavated by a large, rounded depression, encroaching above upon the margin of the tibial articular face.

Below this depression, the bone is expanded, and presents a rounded and convex articular surface, in close relation with the adjoining, and nearly or quite confluent, face for articulation with the navicular, as shown in figure 140, t' below. This convex facet apparently supported a separate bone, as in the existing *Hyrax* (figure 155, Chapter XIV). This bone, as Baur has suggested, probably represents the tibiale, or inner tarsal of the proximal row. The same bone exists also in *Hystrix*, and many other Rodents, and is regarded by Flower as a sesamoid.

The inferior surface of the astragalus (Plate XLVII, figure 3) articulated with three bones; below, with the upper faces of the calcaneum, and, in front, with the navicular and the cuboid. All these articular faces may be confluent, as in the specimen figured on the Plate, and the mode of union with the calcaneum is subject to considerable variation.

In the specimen there figured, the face for the calcaneum may be briefly described as in the form of a horse-shoe with the lateral branches so broad as to leave only a narrow interval between them.

The lateral portions, or branches, present two oval, concave faces, and they are united behind by a broad band, running around the posterior end of a deep, narrow groove, dividing the anterior parts of the articulation, and leading backward to a foramen through the bone. In the specimen figured, this foramen is small and oblique, and no opening is seen through the bone. Along the outer, or fibular, margin of the bone, the articular face is confluent for a short distance with that for the fibula on the side of the astragalus. Near the center of the inferior surface, the inner ramus of the calcaneal articular facet is confluent at the end with the face for the cuboid.

Another, and more common, form of articulation with the calcaneum is shown in figure 140, below, where the lower surface of the astragalus presents two distinct faces for the calcaneum. The outer of these is broad and rounded, nearly flat transversely, concave from before backward, and separated by a deep groove from the inner, more elongated surface. This groove leads backward into a large foramen, passing through the posterior part of the bone. The inner portion of the calcaneal face is longer than the outer, and more concave from before backward. From side to side, it is nearly flat, and, in front, it is more or less confluent with the face for the cuboid, and often also with that for the navicular. In a few specimens, the usual foramen near the hinder border of the bone is represented by a notch only, as in figures 141 and 142, below.

The anterior part of the under surface of the astragalus presents two flattened, moderately convex, and very unequal, articular faces. The larger one of these is for articulation with the navicular, and the smaller, for the cuboid bone.

The presence of a face for the cuboid is in strong contrast with the structure of the foot of the elephant, in which the cuboid is supported by the calcaneum, and the navicular which covers the whole anterior face of the astragalus, not allowing the cuboid to come in contact with that bone. In the *Dinocerata*, this specialization does not occur.

The face for the navicular is fully twice as large as that for the cuboid. It is somewhat convex from side to side, but is nearly flat from before backward, and is bounded along its outer, or fibular, and posterior side by a low rounded ridge, indicating the limit of the cuboid face. This facet is more or less triangular in outline, the apex pointing backward and inward. It is only moderately convex.

The relation of the navicular face to the articulation for the tibiale bone is well shown in woodcuts 140 and 142, below.

The outer, or fibular, side of the astragalus (Plate XLVII, figure 4) presents a convex articulation for the fibula. This face is confluent above, with the tibial surface, and usually, also, in a much less degree, with the outer face for the calcaneum. In some specimens, however (numbers 1248, 1528, 1531), these faces are quite separated.

In an anterior view of the astragalus (figure 5), the exterior, or dermal, surface is seen to be very short, proportionally shorter than in the elephant, but varying within such limits that the longest in the *Dinocerata* may nearly or quite equal in length the shortest in the elephant.

Posteriorly, the astragalus extends backward much farther on the inner, or tibial, side than on the outer side, and is tuberculated. This surface of the bone is, in some specimens, deeply notched near the middle, as in figures 141 and 142, below, but more commonly the notch is converted into a foramen by a bridge of bone, as in Plate XLVII, figure 6, and figures 139 and 140, below. The tibial articular surface is not usually confluent with the calcaneal surface, as is sometimes the case in the elephant. A near approach to confluence is seen in one specimen, number 1209.

The astragalus in *Coryphodon* is very similar in form to that in the *Dinocerata*, but is shorter. It has essentially the same articular faces, and the facet for the tibiale is equally well marked. The hind foot of *Coryphodon* is shown in figure 151, in Chapter XIV. Its general resemblance to the corresponding foot in *Dinoceras* is striking, and the structure of the two is essentially the same. The resemblance between the fore foot of *Dinoceras* and that of *Coryphodon* is equally marked.

The astragalus in one individual of *Dinoceras*, and in one of *Tinoceras*, is represented in the woodcuts below.

Fig. 139.

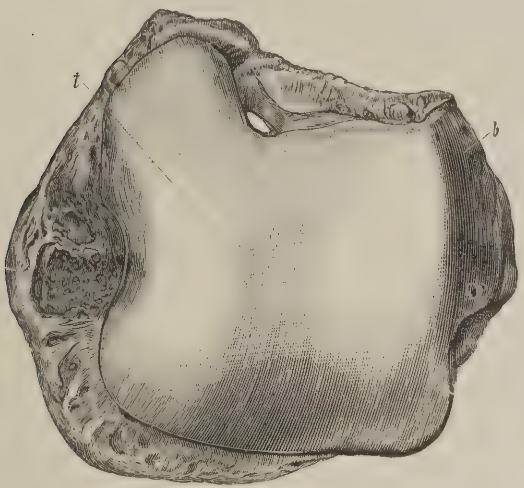


Fig. 140.

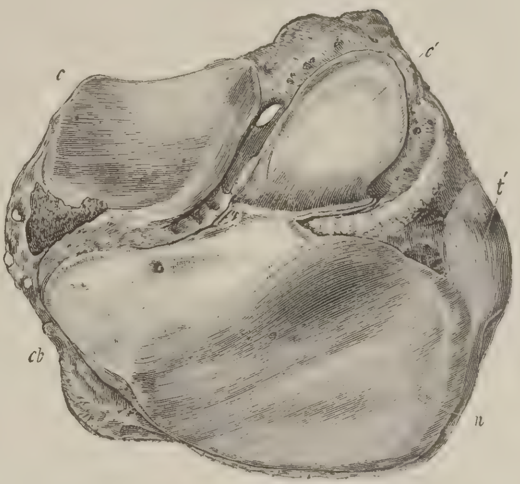


Figure 139.—Left astragalus of *Dinoceras laticeps*, Marsh (No. 1197); top view; showing foramen.
Figure 140.—The same bone; bottom view.

b. face for fibula; *c.* and *c′.* faces for calcaneum; *cb.* face for cuboid; *n.* face for navicular; *t.* face for tibia, *t′.* face for tibiale.

Fig. 141.

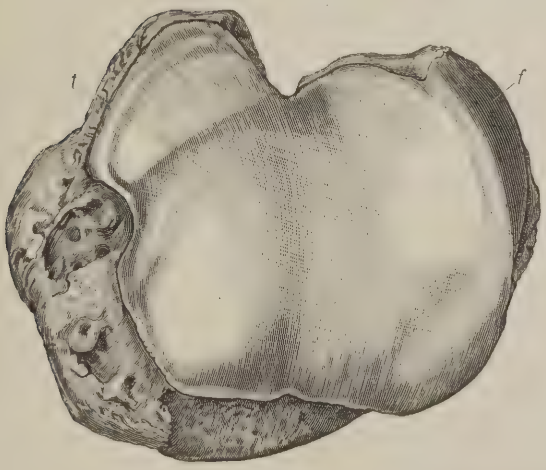


Fig. 142.

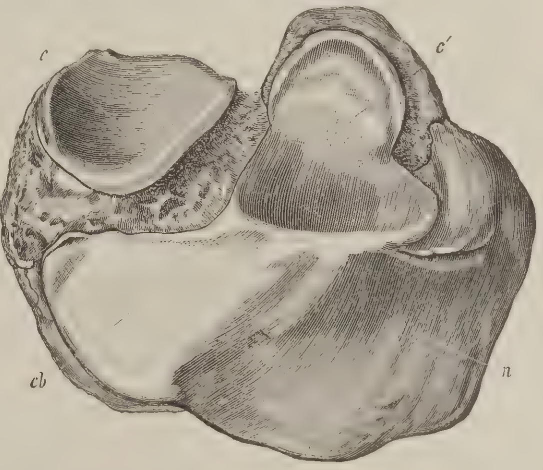


Figure 141.—Left astragalus of *Tinoceras ingens*, Marsh (No. 1209); top view.
Figure 142.—The same bone; bottom view.

c. and *c′.* faces for calcaneum; *cb.* face for cuboid; *f.* face for fibula; *n.* face for navicular, *t,* face for tibia.

All the figures are one-half natural size.

Measurements of the astragalus in four individuals of the *Dinocerata* are as follows:

Measurements of the Left Astragalus. (*Dinoceras mirabile*, No. 1210.)

	m.
Greatest antero-posterior diameter of astragalus,	.112
Greatest transverse diameter,	.121
Greatest vertical diameter,	.070
Greatest diameter of articular face for tibia,	.110
Antero-posterior diameters of articular face for tibia,	.072–.066–.092
Transverse diameters of articular face for tibia,	.076–.071–.085
Antero-posterior diameter of articular face for fibula,	.044
Vertical diameter of articular face for fibula,	.036
Antero-posterior diameter of articular face for calcaneum,	.054
Transverse diameter of articular face for calcaneum,	.080
Transverse diameter of articular face for calcaneum, outer lobe,	.033
Transverse diameter of articular face for calcaneum, inner lobe,	.040
Diameter of band connecting lobes,	.018
Antero-posterior diameter of united faces for navicular and cuboid,	.056
Transverse diameter of united faces for navicular and cuboid,	.107
Diameters of face for navicular,	.056–.082
Diameters of face for cuboid,	.035–.062
Minimum length of neck,	.014

Measurements of Left Astragalus. (*Dinoceras laticeps*, No. 1197.)

	m.
Greatest antero-posterior diameter of astragalus,	.128
Greatest transverse diameter,	.128
Greatest vertical diameter,	.080
Greatest diameter of articular face for tibia,	.127
Antero-posterior diameters of articular face for tibia,	.089–.080–.105
Transverse diameters of articular face for tibia,	.090–.085–.091
Antero-posterior diameter of articular face for fibula,	.055
Vertical diameter of articular face for fibula,	.031
Antero-posterior diameter of outer articular face for calcaneum,	.053
Transverse diameter of outer articular face for calcaneum,	.048
Antero-posterior diameter of inner articular face for calcaneum,	.061
Transverse diameter of inner articular face for calcaneum,	.035
Distance between inner and outer faces for calcaneum,	.009
Antero-posterior diameter of united faces for navicular and cuboid,	.072
Transverse diameter of united faces for navicular and cuboid,	.113
Diameters of face for navicular,	.064–.091
Diameters of face for cuboid,	.031–.071
Minimum length of neck,	.016

Measurements of Left Astragalus. (*Tinoceras ingens*, No. 1209.)

	m.
Greatest antero-posterior diameter of astragalus,	.122
Greatest transverse diameter,	.147
Greatest vertical diameter,	.083
Greatest diameter of articular face for tibia,	.125
Antero-posterior diameters of articular face for tibia,	.091–.082–.104
Transverse diameters of articular face for tibia,	.094–.096–.095
Antero-posterior diameter of articular face for fibula,	.060
Vertical diameter of articular face for fibula,	.039
Antero-posterior diameter of outer articular face for calcaneum,	.050
Transverse diameter of outer articular face for calcaneum,	.050
Antero-posterior diameter of inner articular face for calcaneum,	.058
Transverse diameters of inner articular face for calcaneum,	.033–.050
Distance between inner and outer faces for calcaneum,	.018
Antero-posterior diameter of united faces for navicular and cuboid,	.068
Transverse diameter of united faces for navicular and cuboid,	.130
Diameters of face for navicular,	.068–.105
Diameters of face for cuboid,	.042–.077
Minimum length of neck,	.019

Measurements of Right Astragalus. (*Dinoceras mirabile*, No. 1528.)

	m.
Greatest antero-posterior diameter of astragalus,	.100
Greatest transverse diameter,	.108
Greatest vertical diameter,	.063
Greatest diameter of articular face for tibia,	.100
Antero-posterior diameters of articular face for tibia,	.070–.060–.093
Transverse diameters of articular face for tibia,	.067–.067–.070
Antero-posterior diameter of articular face for fibula,	.040
Vertical diameter of articular face for fibula,	.030
Antero-posterior diameter of outer articular face for calcaneum,	.035
Transverse diameter of outer articular face for calcaneum,	.039
Antero-posterior diameter of inner articular face for calcaneum,	.040
Transverse diameter of inner articular face for calcaneum,	.040
Antero-posterior diameter of united articular faces for navicular and cuboid,	.053
Transverse diameter of united articular faces for navicular and cuboid,	.093
Diameters of face for navicular,	.076–.053
Diameters of face for cuboid,	.026–.055
Minimum length of neck,	.015

The Calcaneum.

(Plate XLVIII, Plate LIV, figure 2, *c;* and woodcuts 143–144, below.)

The calcaneum in the *Dinocerata* is short, and comparatively more robust, than in the elephant. As in that animal, it is strongly tuberculated

below, where, during life, it doubtless supported a thick pad, resting on the ground.

The calcaneum articulated mainly with two bones, the astragalus and the cuboid. Some specimens, and perhaps all, present a small face where the fibula touched this bone.

The articulation with the astragalus is, in most specimens, divided into two distinct facets (figures 144, *a* and *a′*) by a deep groove. In some cases, however, these facets are coalescent posteriorly, as in Plate XLVIII, figures 1 and 5, and in figure 143, corresponding with a similar coalescence of faces on the astragalus.

The face for the cuboid is small, and irregularly rounded, or oval, as seen in Plate XLVIII, figure 1, and is usually more or less confluent with the inner face for the astragalus, but is well separated from the outer face for that bone.

The great tuberosity for the attachment of the tendo Achillis is very short, proportionally shorter than in the elephant.

FIG. 143.

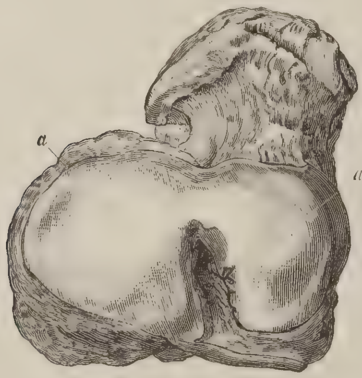


FIG. 144.

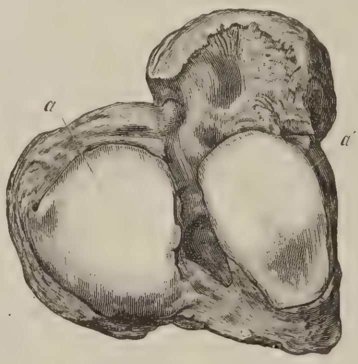


FIGURE 143.—Calcaneum of *Dinoceras mirabile*, Marsh (No. 1210); top view.
FIGURE 144.—Calcaneum of *Dinoceras mirabile*, (No. 1208); top view.
a, and *a′*, faces for astragalus.
Both figures are one-half natural size.

Two specimens of the calcaneum in different individuals of *Dinoceras* are represented in the woodcuts above.

Measurements of three specimens of the calcaneum in the *Dinocerata* are as follows:

Measurements of Left Calcaneum. (*Dinoceras mirabile*, No. 1210.)

	m.
Length of calcaneum, from great tuberosity to face for cuboid,	.096
Transverse diameter,	.090
Vertical diameter,	.070
Antero-posterior diameter of inner lobe of articulation for astragalus,	.050
Transverse diameter of inner lobe of articulation for astragalus,	.043
Antero-posterior diameter of outer lobe of articulation for astragalus,	.043
Transverse diameter of outer lobe of articulation for astragalus (approximate),	.039

Measurements of Right Calcaneum. (*Dinoceras mirabile*, No. 1225.)

	m.
Length of calcaneum, from great tuberosity to face for cuboid,	.107
Transverse diameter (approximate),	.086
Vertical diameter,	.074
Antero-posterior diameter of inner face for astragalus,	.053
Transverse diameter of inner face for astragalus,	.037
Antero-posterior diameter of outer face for astragalus,	.045
Transverse diameter of outer face for astragalus (approximate),	.037
Distance between inner and outer faces for astragalus,	.010

Measurements of Left Calcaneum. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of calcaneum, from great tuberosity to face for cuboid,	.093
Transverse diameter,	.086
Vertical diameter,	.074
Antero-posterior diameter of inner face for astragalus,	.044
Transverse diameter of inner face for astragalus,	.042
Antero-posterior diameter of outer face for astragalus,	.050
Transverse diameter of outer face for astragalus,	.032
Distance between faces for astragalus,	.070
Transverse diameter of face for cuboid,	.035
Vertical diameter of face for cuboid,	.019

The Cuboid.

(Plate XLIX, figures 1–6, Plate LIV, figure 2, *cb;* and woodcuts 145–146, below.)

The cuboid in the *Dinocerata* corresponds in general with that of the elephant, and presents similar articular faces, though not to the same bones. It is also more elongated in the line of the axis of the foot, thus appearing less flattened than in the *Proboscidea*. In general shape, the bone is triangular, the longest side being nearly straight, and lying along the inner, or side for the navicular, while the shortest side is somewhat curved, and is presented to the exterior, or dorsal, surface of the foot.

This surface (Plate XLIX, figure 1) is moderately roughened, especially at the edges, for attachments of ligaments. The outer, or fibular, side, shown best in figure 4, is short along the line of the foot, being encroached upon by the articular face for the calcaneum on the proximal end, and one for the fifth metatarsal on the distal end.

The plantar aspect of the bone (figure 3) presents a single, or bifid, tubercle, and, on the inner face (figure 2), is an elongate articular surface for union with the navicular. This surface is confluent with the face for articulation with the astragalus, and thus serves to distinguish the proximal from the distal end of the bone, which often closely resemble each other.

The proximal surface (figure 5) is covered by two articular facets. The inner one, large and sub-triangular, concave in both directions, and nearly perpendicular to the axis of the bone, moved, during life, upon the outer distal face of the astragalus. This face is, in the specimen figured on the Plate, widely confluent with a smaller oval face for the calcaneum. In figure 146, below, the face for the calcaneum (*c*) is much less widely confluent with that for the astragalus, being nearly separated from it. In both specimens, the calcaneal face is slightly convex transversely, and somewhat inclined to the axis of the bone.

FIG. 146.

FIG. 145.

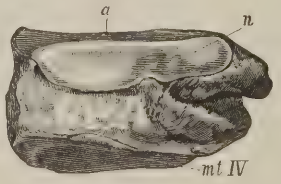


FIGURE 145.—Right cuboid of *Dinoceras mirabile*, Marsh (No. 1528); side view
FIGURE 146.—The same bone; proximal end.
a. face for astragalus; *c*. face for calcaneum; *mt* IV. face for fourth metacarpal; *n*. face for navicular.
Both figures are one-half natural size.

The cuboid bone in one individual of *Dinoceras* is represented in the two cuts above.

The distal face (Plate XLIX, figure 6) also presents two articular surfaces, for the support of the fourth and fifth metatarsal bones. The

face for the fourth metatarsal is much the larger. It is narrow, or pointed, below, and moderately concave, or, in the lower part, slightly convex, from above downward, and is at right angles with the axis of the bone. The smaller outer face, supporting the fifth metatarsal, is turned somewhat outward, and is slightly convex in both directions.

The principal dimensions of the two cuboid bones above described are as follows:

Measurements of Left Cuboid. (*Dinoceras mirabile*, No. 1208.)

	m.
Length of cuboid, along axis of foot,	.035
Transverse diameter,	.054
Antero-posterior diameter,	.060
Antero-posterior diameter of face for astragalus,	.055
Transverse diameter of face for astragalus,	.034
Antero-posterior diameter of face for cuboid,	.035
Transverse diameter of face for cuboid,	.020
Antero-posterior diameter of face for fourth metatarsal,	.049
Transverse diameter of face for fourth metatarsal,	.032
Antero-posterior diameter of face for fifth metatarsal,	.035
Transverse diameter of face for fifth metatarsal,	.022

Measurements of Right Cuboid. (*Dinoceras mirabile*, No. 1528.)

	m.
Length of cuboid, along axis of foot,	.037
Transverse diameter,	.066
Antero-posterior diameter,	.065
Antero-posterior diameter of face for astragalus,	.058
Transverse diameter of face for astragalus,	.036
Antero-posterior diameter of face for cuboid,	.032
Transverse diameter of face for cuboid,	.026
Antero-posterior diameter of face for fourth metatarsal,	.049
Transverse diameter of face for fourth metatarsal,	.035
Antero-posterior diameter of face for fifth metatarsal,	.039
Transverse diameter of face for fifth metatarsal,	.032

The Navicular.

(Plate XLIX, figures 7–12, and Plate LIV, figure 2, *n*.)

The navicular is a short bone in the *Dinocerata*, strongly flattened vertically, much as in the elephant. It is supported by the astragalus, and does not usually, as in that animal, touch the calcaneum. It supports only the three cuneiform bones in front, but presents a narrow, lateral, articular face to the cuboid.

The surface of the navicular exposed upon the dorsal aspect of the foot (Plate XLIX, figure 7) is short vertically, more or less rounded from side to side, and varies much in the degree of smoothness, or tuberculation, in different specimens.

The under, or plantar, surface, shown in figure 9, projects into a large rounded tubercle, and is of considerably greater extent along the axis of the foot than above.

The outer surface (figure 10), presented to the cuboid, is more or less covered by an articular face, extending along the proximal margin of the bone, confluent with the astragalar face, and, in life, moving upon a corresponding face upon the inner side of the cuboid.

The proximal surface of the bone (figure 11) is mostly occupied by a large articular surface, for union with the astragalus. This surface is somewhat saddle-shaped, being distinctly concave transversely, but somewhat convex from above downward. Below the articular face, the bone usually extends into a strong plantar tubercle, which may, however, (number 1218) be much less developed than in the specimen figured.

None of the specimens present any indication, on the proximal face, of a surface for articulation with the calcaneum, such as is found on the corresponding bone of the elephant.

The distal surface of the navicular (figure 12) presents three articular faces, one for each of the cuneiform bones. These faces are confluent with each other, and the inner one, for the entocuneiform, may be small, and indistinct. Usually, it is of considerable size, and elongated from above downward. It is oval in shape, moderately convex in both directions, and oblique to the axis of the bone, looking somewhat outward.

The median of the three faces is sub-quadrate in outline, a little broader above than below, and confluent, on each side, with the adjacent faces. This face is slightly concave from side to side, and from above downward, nearly flat.

The face for the ectocuneiform is sub-quadrate, tapering below, concave in both directions, or nearly flat from above downward.

These faces may all be considerably shorter and broader than in the specimen figured, and the face for the entocuneiform may be very greatly reduced.

The following measurements of three specimens of the navicular in *Dinoceras* show the more important dimensions of this bone:

Measurements of Left Navicular. (*Dinoceras mirabile*, No. 1247.)

	m.
Transverse diameter of navicular,	.085
Antero-posterior diameters (axial),	.015–.029
Transverse diameter of face for astragalus,	.080
Vertical diameter of face for astragalus,	.060
Transverse diameter of face for entocuneiform,	.020
Vertical diameter of face for entocuneiform,	.050
Transverse diameter of face for mesocuneiform,	.025
Vertical diameter of face for mesocuneiform,	.045
Transverse diameter of face for ectocuneiform,	.035
Vertical diameter of face for ectocuneiform (approximate),	.055

Measurements of Left Navicular. (*Dinoceras mirabile*, No. 1208.)

	m.
Transverse diameter of navicular,	.067
Antero-posterior diameters,	.015–.025
Vertical diameter,	.069
Transverse diameter of face for astragalus,	.058
Vertical diameter of face for astragalus,	.051
Transverse diameter of face for entocuneiform,	.022
Vertical diameter of face for entocuneiform,	.033
Transverse diameter of face for mesocuneiform,	.026
Vertical diameter of face for mesocuneiform,	.043
ransverse diameter of face for ectocuneiform,	.032
Vertical diameter of face for ectocuneiform,	.040

Measurements of Left Navicular. (*Dinoceras mirabile*, No. 1218.)

	m.
Transverse diameter of navicular,	.082
Antero-posterior diameters,	.015–.022
Vertical diameter,	.065
Transverse diameter of face for astragalus,	.065
Vertical diameter of face for astragalus,	.050
Transverse diameter of face for entocuneiform (approximate),	.012
Vertical diameter of face for entocuneiform,	.028
Transverse diameter of face for mesocuneiform,	.029
Vertical diameter of face for mesocuneiform (approximate),	.045
Transverse diameter of face for ectocuneiform,	.037
Vertical diameter of face for ectocuneiform,	.052

The Entocuneiform.

(Plate L, figures 1–6, and Plate LIV, figure 2, *en.*)

The entocuneiform in the *Dinocerata* bears but slight resemblance to the corresponding bone in the elephant. It is much less elongated in the line of the axis of the foot, and even less so than appears in the general view of the hind foot on Plate LIV, since the elongation apparent in that figure is, to a great extent, in front of the articular surfaces. These surfaces are, at their nearest points, scarcely more widely separated in the direction of the axis of the foot, than are those of the other cuneiform bones.

The dermal surface of the bone (Plate L, figure 1) is rough and tuberculated, often much more so than represented in the figure. It is also usually more elongated in the axial direction, in front of the articular surfaces.

The opposite surface of the bone (figure 3) is flattened, and moderately roughened, and presents a small area only for articulation with the mesocuneiform. This articular face is confluent with the face for the navicular, and lies along the anterior part of its margin.

The proximal articular face (figure 5) is of a semi-oval form, and is more or less concave in a direction from the dorsal toward the plantar side of the foot, while transversely it is moderately convex.

The distal face (figure 6) is much more distinctly saddle-shaped. In some specimens, it is strongly curved forward in the superior region of the bone, so as to extend through a considerable arch in the direction from the dorsal toward the plantar side of the foot. Transversely, the articulation is moderately convex throughout.

The Mesocuneiform.

(Plate L, figures 7–12.)

The mesocuneiform is a small, somewhat wedge-shaped bone, tapering toward its plantar extremity, and having its shortest dimension in the line of the axis of the foot. It is much less oblique than the corresponding bone in the elephant, and also less decidedly wedge-shaped.

The dorsal surface of the bone (Plate L, figure 7) is rugose and tuberculated, and the plantar extremity (figure 9) also presents a rather prominent protuberance.

Of the lateral faces, the inner (figure 8), turned toward the entocuneiform, presents, along the proximal part of its margin, a more or less elongated facet, for articulation with that bone. The opposite side (figure 10) turned toward the ectocuneiform, is moderately rough, and destitute of any articular face.

The proximal articular face (figure 11) is nearly flat, slightly broader above than below, and, along the inner margin, confluent with the lateral face for articulation with the entocuneiform.

The distal face (figure 12) is also nearly flat, and, in life, supported in part, but not entirely, the second metatarsal bone. The latter presented nearly as large a face to the ectocuneiform, as to the mesocuneiform.

The following measurements give the principal dimensions of this bone in two specimens of *Dinoceras mirabile*:

Measurements of Left Mesocuneiform. (*Dinoceras mirabile*, No. 1210.)

	m.
Greatest diameter of mesocuneiform,	058
Transverse diameter,	.032
Antero-posterior diameters (axial),	.014–.020

Measurements of Left Mesocuneiform. (*Dinoceras mirabile*, No. 1208.)

	m.
Greatest diameter of mesocuneiform,	.053
Transverse diameter,	.026
Antero-posterior diameters (axial),	.014–.018

The Ectocuneiform.

(Plate L, figures 13–18.)

The ectocuneiform is triangular in outline, tapering distinctly, and in most specimens nearly to a point, toward the palmar surface of the foot. It is much less oblique than the corresponding bone in the elephant, and usually has the two distal faces more distinctly marked. It is also proportionally less elongated from the dorsal toward the plantar side of the foot.

The dorsal, or dermal, face (Plate L, figure 13) is roughened for ligamentary attachment, and on the opposite, or plantar, side, the bone is produced into a more or less prominent tubercle (figure 15). In the natural position, during life, this elevation was just back of the proximal end of the third metatarsal.

The lateral surfaces of the ectocuneiform (figures 14 and 16) are moderately roughened, and do not present articular surfaces for either the mesocuneiform on the inner side, or for the cuboid on the outer side.

The proximal articular face (figure 17) is nearly flat, or slightly convex transversely, while, in a dorso-plantar direction, it may be more or less concave.

The distal surface (figure 18) presents two confluent, but usually well marked, articular surfaces. Of these, the inner is narrow and oblique, and supported, in life, the outer part of the second metatarsal. The principal articular face of the distal end is nearly flat, sub-triangular in outline, and narrowed toward the plantar end. In life, it supported the third metatarsal bone.

The tubercle upon the plantar side of this bone differs considerably in size and form (numbers 1202 and 1229). The degree of distinction between the two distal faces also varies in different specimens (numbers 1208, 1232, and 1199).

The more important measurements of the ectocuneiform in four specimens of *Dinoceras* are given below.

Measurements of Right Ectocuneiform. (*Dinoceras mirabile*, No. 1199).

	m.
Greatest diameter of ectocuneiform,	.066
Transverse diameter,	.045
Antero-posterior diameters,	.014–.026
Diameters of proximal articular face,	.030–.048

Measurements of Left Ectocuneiform. (*Dinoceras laticeps*, No. 1202.)

	m.
Greatest diameter of ectocuneiform,	.060
Transverse diameter,	.040
Antero-posterior diameters,	.017–.024
Diameters of proximal articular face,	.033–.050

Measurements of Left Ectocuneiform. (*Dinoceras mirabile*, No. 1208.)

	m.
Greatest diameter of ectocuneiform,	.055
Transverse diameter,	.035
Antero-posterior diameters,	.016–.021
Diameters of proximal articular face,	.028–.039

Measurements of Left Ectocuneiform. (*Dinoceras mirabile*, No. 1232.)

	m.
Greatest diameter of ectocuneiform,	.064
Transverse diameter,	.044
Antero-posterior diameters (axial),	.014–.022
Diameters of proximal articular face,	.032–.046

The First Metatarsal.

(Plate LI, figures 1–6, and Plate LIV, figure 2.)

The first metatarsal bone of the *Dinocerata* is the shortest and smallest of the five, but is comparatively much better developed than in the elephant.

The first metatarsal in *Dinoceras mirabile* is short and stout, and strongly roughened on all sides throughout its length, as seen in Plate LI, figures 1–4. As in the other metatarsals preserved, there are no distinct indications of epiphysial sutures.

This bone does not appear, during life, to have been in very close relation with the adjoining metatarsal, and accordingly presents, on its proximal end (figure 5), only a single articular surface, which is distinctly saddle-shaped, and joined the entocuneiform.

The distal end (figure 6) presents a flattened, and somewhat concave, face for the first phalanx, and immediately below this, are grooves for a pair of sesamoid bones.

The Second Metatarsal.

(Plate LI, figures 7–12, and Plate LIV, figure 2.)

The second metatarsal in *Dinoceras* is the most robust of the series, and is a short, and very stout bone.

The surface of the shaft, as seen in Plate LI, figures 7–10, is

roughened at both the proximal and distal ends, but medially it is smoother and constricted, especially below, where a large, and prominent, tubercle occupies the proximal portion of the under surface of the bone. This tubercle is shown in figure 9, and also, in profile, in figures 8 and 10, where it is seen to project considerably beyond the proximal articular face.

The proximal end of the bone (figure 11) is oblique to its axis, and presents two distinct articular faces; the larger on the inner, or tibial, side of the bone, for the mesocuneiform, and the outer, on the fibular side, for the ectocuneiform. The latter face is also confluent with a lateral facet, where the bone, during life, touched the third metatarsal. This face is well shown in figure 10.

The distal end (figure 12) is large, rounded, and somewhat oblique to the axis of the bone. The articulation for the phalanx is flattened, but may be slightly convex, or, in a transverse direction, more or less concave. Two well developed sesamoids moved in broad shallow grooves below, the faces for these bones, taken together, being about as large as that for the phalanx.

The Third Metatarsal.

(Plate LI, figures 13–15, Plate LII, figures 1–3, and Plate LIV, figure 2.)

The third metatarsal is of about the same length as the second and the fourth, and is a little less robust than the second.

It has a distinct shaft, which is smooth and constricted medially, but more or less roughened and tubercular toward the extremities, especially near the distal end.

The proximal face of the bone (Plate LII, figure 2) is somewhat oblique to its axis, and presents a sub-triangular articular face for the outer facet of the ectocuneiform. This facet is confluent, along its inner margin, with a small lateral face for union with the second metatarsal, as shown in Plate LI, figure 14. Opposite this, there is also an oval face (Plate LII, figure 1) supported on a flattened tubercle, and meeting, during life, a similar face on the fourth metatarsal.

The distal end (Plate LII, figure 3) is large and rounded, and, in some specimens, distinctly oblique. It supports the usual face for the first phalanx, and below, two shallow grooves for a pair of sesamoid bones. The phalangeal face is, in all the specimens preserved, distinctly, though slightly, convex in both directions.

The Fourth Metatarsal.

(Plate LII, figures 4–9, and Plate LIV, figure 2.)

The fourth metatarsal is of about the same size as the third, and considerably resembles it in structure This resemblance is much greater than in the elephant, where the fourth is decidedly shorter than the third metatarsal.

The shaft of the fourth metatarsal is strongly constricted medially, as seen in Plate LII, figures 5 and 7, and bears on the under side, at the proximal end, a large projecting tubercle.

The proximal end (figure 8) bears a nearly flat articular surface, sub-triangular in outline, and nearly perpendicular to the long axis of the bone, and articulating, during life, with the cuboid bone. This surface is confluent on the outer side with a small lateral facet shown in figure 7, which corresponds with a similar face on the fifth metatarsal. On the opposite, or inner side, is an oval facet (figure 5) articulating in life, with a prominent face on the third metatarsal.

The distal end of the fourth metatarsal (figure 9) is but little oblique to the axis of the bone, and bears the usual faces, for articulation with the phalanx, and the sesamoids. The phalangeal articulation may be concave from side to side (number 1199), but is usually slightly convex in both directions.

The Fifth Metatarsal.

(Plate LII, figures 10–15, and Plate LIV, figure 2.)

The fifth metatarsal in *Dinoceras* is shorter than any of the others except the first, but is robust, and evidently afforded its full share of support to the foot.

Its surface is strongly tuberculated, especially on the under and outer sides, as shown in Plate LII, figures 12 and 13. The shaft, being short, does not present a median constriction, as in the three preceding metatarsals.

The proximal end (figure 14) bears a comparatively small articular face for support on the cuboid bone. This face is nearly flat, and somewhat quadrangular in outline, and is confluent, on the inner margin, with a small lateral face for the fourth metatarsal, as seen in figure 11. The proximal articular face is nearly at right angles to the axis of the bone.

The distal face (figure 15) for the proximal phalanx is turned strongly outward, and is more or less concave. The sesamoid grooves, also, look strongly outward, and the inner is larger than the outer.

The Phalanges.

(Plates LII–LVI.)

The phalanges of the hind foot in the *Dinocerata* are very similar to those of the fore foot, although smaller, and hence need no detailed description. In Plate LIII, these bones are well represented, and with them, some of the sesamoid bones of the same feet. In Plate LIV, figure 2, the phalanges are shown in position, and other views of them may be seen in the two restorations on Plates LV and LVI.

CHAPTER XIII.

RESTORATIONS OF DINOCERAS AND TINOCERAS.

(Plates LV and LVI.)

The preceding chapters of this memoir, and the illustrations given in Plates I–LIV, will make known to anatomists nearly all the important characters in the skeleton of the gigantic mammals of the order *Dinocerata.* In Plate LV, a restoration is given of *Dinoceras mirabile*, the type of the group, and, in Plate LVI, one also of *Tinoceras ingens*, a characteristic, and more specialized form of an allied genus.

The remains available for these restorations consist of portions of more than two hundred individuals of the *Dinocerata.* As none of the skeletons of the species here represented were complete when found, it has been necessary to use, in both restorations, the bones of other individuals which could not be distinguished from the type specimens. Some of these bones may, perhaps, belong to allied forms, but it is believed that the restorations, as here given, fairly represent the skeletons of the species named.

In the restoration of *Dinoceras mirabile* on Plate LV, the remains of the type specimen of the species, a fully adult, but not old individual, have been used for the more important parts, and the remaining portions taken from other individuals. This restoration is one-eighth natural size.

The animal is represented as walking, and the position of the head, and the feet, has been chosen to show, to the best advantage, these portions of the skeleton as they were in life. In this restoration, only those portions are shaded which are represented by actual specimens in the Yale Museum. The parts in outline are either wanting, or so poorly preserved that only their main features can be given with accuracy.

In the restoration of *Tinoceras ingens*, Plate LVI, the animal is represented one-sixth natural size, and standing at rest. The position here chosen shows the massive and majestic form of one of the largest individuals of this remarkable group. Here, likewise, the shaded portions are represented by specimens in the Yale Museum. Some of these bones were used also in the first restoration.

In comparing *Dinoceras*, as here restored, with some of the largest ungulate mammals of the present day, a certain resemblance to the rhinoceros on the one hand, and to the elephant on the other, will naturally suggest itself. In size and proportions, *Dinoceras* was intermediate between these two existing animals, and in various points of its structure, it resembled the one quite as much as the other. In still other features, *Dinoceras* resembled the hippopotamus, and its affinities with the groups represented by these three types will be discussed in the succeeding chapter.

In its stature and movements, *Dinoceras* probably resembled the elephant as much as any other existing form. Its remarkable skull, longer neck, and more bent fore limbs, gave it, however, a very different appearance from any known Proboscidian. The high protuberances on the head, the long trenchant canine tusks, and the peculiar lower jaw modified for their protection, are features seen together only in this group.

The neck was long enough to permit the head to reach the ground, and hence a proboscis was quite unnecessary. The horizontal narial opening, the long overhanging nasal bones, and the well developed turbinal bones, are likewise proof positive against the presence of such an organ. There is some evidence of a thick flexible lip, resembling, perhaps, that of the existing rhinoceros.

The remarkably small brain, and the heavy massive limbs, indicate a dull, slow-moving animal, little fitted to withstand sudden changes in its environment, and hence it did not survive the alterations of climate with which the Eocene period closed.

That the *Dinocerata* were very abundant for a long time during the middle Eocene is proved, conclusively, by their numerous remains in deposits of this age. That the animals lived in herds is also suggested by the position in which the remains are found. Their favorite resorts would seem to have been around the borders of the great Eocene tropical lake described in the Introduction of the present volume. Here, they found an abundance of food, which was evidently the soft succulent vegetation which flourished, then as now, in such localities.

In *Tinoceras*, represented in Plate LVI, we have the skeleton of a larger, and still more imposing animal, but with essentially the same characteristics. The remains of this genus are found in the same lake-basin as those of *Dinoceras*, but at a higher level, and the evidence is clear that *Tinoceras* is a later, and more specialized form.

Both the animals chosen for these two restorations were evidently males, as shown by the lofty protuberances, or horn-cores, on the skull, and the powerful canine tusks. In the females, these parts are but feebly developed, as seen in the specimens described in the preceding chapters. The individuals here restored were certainly thrice-armed, and well fitted to protect themselves, and their weaker associates, from any of their Eocene enemies.

The exact form and nature of the offensive weapons which surmounted the head of the *Dinocerata* cannot, at present, be determined with certainty. That the paired osseous elevations on the skull in all the known species of this group did not support the kind of horns seen in the typical Ruminants is evident from their external surface, which lacks the vascular grooves so distinct on the horn-cores of those animals.

Possibly the *Dinocerata* may have been armed with horns similar to those seen in the American antelope *(Antilocapra)*, since, in this animal, the horn-cores are even smoother than in the order here described. More probably, however, the bony protuberances on the skull were covered with bosses of thick skin, hard enough to be effective in combat. Evidence of such contests has apparently been recorded in the injuries to the horn-cores of some individuals, received during life. None of the covering of these elevations, or horn-cores, has, of course, been preserved; yet a fortunate discovery may, perhaps, reveal their nature by the form of a natural cast, as the eye-ball of the Oreodon is sometimes thus clearly indicated in the fine Miocene matrix which envelops these animals.

The short robust feet of the *Dinocerata* were doubtless covered below with a thick pad, as in the elephant, since the whole under side of the foot clearly indicates such a protection. No portion of this covering has been preserved in any of the known specimens, and no foot-prints, indicating its form, have been discovered in the Eocene deposits in which the *Dinocerata* were entombed.

The size of *Tinoceras ingens*, as he stood in the flesh, was about twelve feet (3.65 M.) in length, or sixteen (4.9 M.), measured from the nose to the end of the tail. The height to the top of the back was about six and one-half feet (2 M.), and the width across the hips about five feet (1.5 M.). The weight, judging from that of existing mammals, was at least six thousand pounds (2.75 T.).

Dinoceras mirabile was about one-fifth smaller. The neck was longer, but, in other respects, the proportions were nearly the same.

Dinoceras mirabile when standing at rest would have a general resemblance to a very large rhinoceros. When walking, the movement of the hind limbs would at once suggest the elephant, as we know it to-day. The movement of the head in *Dinoceras* was much freer than that in the elephant, as the neck was longer, and arched upward, and the vertebræ admitted of much more freedom of motion. The eye was small, and deep set, as in the rhinoceros. The head of *Dinoceras* must have had some resemblance to that of the hippopotamus, but was very different from that of any known animal, living or extinct.

CHAPTER XIV.

CONCLUSION.

(Plates LIV–LVI, and woodcuts 147–169, below.)

The more important characters of the *Dinocerata*, so far as known, have been given in the preceding chapters, and the anatomist can now form a fair picture of characteristic members of the group. It remains to consider what the relations of this peculiar group are to the nearest allied forms, and, especially, to ascertain, if possible, whether the evidence before us throws any light on the origin of the *Dinocerata*, and, more remotely, on the genealogy of all Ungulate Mammals.

The oldest known mammals are of Triassic age, but the few specimens yet discovered give little information as to the primitive forms of this class. During Jurassic time, mammals were very abundant, and deposits of this age now offer a promising field for exploration.

Of Triassic and Jurassic mammals, the author has studied with some care every known specimen in this country, and in Europe, and some of the conclusions here given are based upon this examination. Special attention has been paid to the Jurassic mammals of this country, which the author first discovered in the Rocky Mountain region. Remains of nearly four hundred individuals, representing many genera and species, have already been secured, and their investigation promises to clear up many doubtful points in the early history of this class.

No Cretaceous mammals are known, and it is this great break in the series of ancient forms that renders any satisfactory classification of the class, living and extinct, at present impossible.

At the very base of the Tertiary, we find the class of Mammals well represented by many widely separated groups, which point back to a common ancestry, only in a very remote period.

Our present knowledge of the *Mammalia*, living and extinct, clearly indicates that they must go back at least to the Permian. The generalized mammal of that period, or of still earlier time, was probably quite small, and, in many respects, like an Insectivor. This primitive type would naturally possess all the general characters found in later forms in the various orders of mammals. The characters therefore we should expect to find in this ancestral mammal would be essentially the following:

(1.) Brain, small and smooth.
(2.) Teeth, more than forty-four.
(3.) Vertebræ, biconcave.
(4.) Trunk vertebræ, more than thirty.
(5.) Sacral vertebræ, separate.
(6.) Intercentral bones.
(7.) Chevron bones.
(8.) Cervical ribs, free.
(9.) Clavicles, free.
(10.) Coracoids, free.
(11.) Sternal bones, flat.
(12.) Humerus with supra-condylar foramen.
(13.) Feet, plantigrade.
(14.) Five digits in manus and in pes.
(15.) Carpal and tarsal bones not interlocking.
(16.) Separate central bone in carpus.
(17.) Pelvic bones, separate.
(18.) Epipubic bones.
(19.) Acetabular bones.
(20.) Femur with third trochanter.
(21.) Three bones in first tarsal row.
(22.) Astragalus, flat.
(23.) Fibula articulating with calcaneum.

This generalized mammal would belong to the group named *Hypotheria* by Huxley, who has laid a sure foundation for investigation in this line of research.

Genealogy of Ungulates.

From this primitive type of mammal, a special line apparently led off through the Triassic and Jurassic to the Cretaceous, where it formed a well marked group, which may be called the *Protungulata*, the probable ancestors of all succeeding Ungulate Mammals.

The characters of this type would be somewhat as follows:

(1.) Brain, small and smooth.
(2.) Teeth, forty-four or more.
(3.) No frontal appendages.
(4.) Odontoid process, conical.
(5.) Vertebræ, flat.
(6.) Trunk vertebræ, thirty or more.
(7.) Chevron bones.
(8.) Clavicles present.
(9.) Sternal bones, flat.
(10.) Humerus with supra-condylar foramen.
(11.) Feet, plantigrade.
(12.) Five digits in manus and in pes.
(13.) Carpal and tarsal bones not interlocking.
(14.) Separate central bone in carpus.
(15.) Femur with third trochanter.
(16.) Three bones in first tarsal row.
(17.) Astragalus, flat.
(18.) Fibula articulating with calcaneum.

From this generalized ungulate, the skeleton of which we now know almost as well apparently as if we had it before us, a direct line would appear to have continued up to the present day, and be represented by the living Hyrax. Several divergent lines passed off probably from the same stem, and three of these have continued to the present time, the survivors being the *Proboscidea*, the *Artiodactyla*, and the *Perissodactyla*.

The Proboscidian line apparently went off from the main ungulate stem in the Cretaceous. One branch ended in the later Pliocene in *Dinotherium;* another, in *Mastodon;* while the genus *Elephas* alone survives, to represent this old group.

Another strong branch, represented by a group which may be called the *Holodactyla*, probably also led off in the Cretaceous, and its typical members, at least, had the following general characters:

(1.) Brain, small and nearly smooth.
(2.) Teeth, forty-four.
(3.) Post glenoid process.
(4.) Odontoid process, conical.
(5.) Vertebræ, flat.
(6.) Trunk vertebræ, twenty-three or more.
(7.) Chevron bones.
(8.) Pelvic bones, firmly united.
(9.) Femur with third trochanter.
(10.) Ulna and fibula, complete.
(11.) Fibula articulating with calcaneum.
(12.) Five digits in manus and in pes.
(13.) Carpal and tarsal bones more or less interlocking.
(14.) Astragalus, nearly or quite flat.

This line evidently divided near the base of the Eocene into the great groups of Perissodactyls and Artiodactyls, each with many off-shoots, and still existing. The former are now on the decline, and have but three living representatives, the horse, the tapir, and the rhinoceros.

One off-set from the Perissodactyl line separated near the top of the Eocene, where it is represented by *Diplacodon*, and perhaps ended in the extinct *Brontotherium*, of the lower Miocene, although this line may have been continued somewhat later in the genus *Chalicotherium.*

From the Artiodactyl line, a peculiar group branched off in the early Eocene, and in the Miocene was represented by *Oreodon* and allied genera, and by later forms in the Pliocene. The Artiodactyls, now the dominant ungulates, have numerous families, and many living genera and species.

Another order, also, which may be termed the *Amblydactyla*, passed off apparently from the main ungulate stem in the Cretaceous, and became extinct in the Eocene. One branch terminated in *Coryphodon*, in the lower Eocene, and the other, represented by the *Dinocerata*, here described, came to an end in the Middle Eocene.

In figure 147, below, a diagram is given, which shows graphically these lines of descent, and the most probable genealogy of modern Ungulates. The diagram, being on a plane, can only indicate the general position of these divergent lines.

Fig. 147.

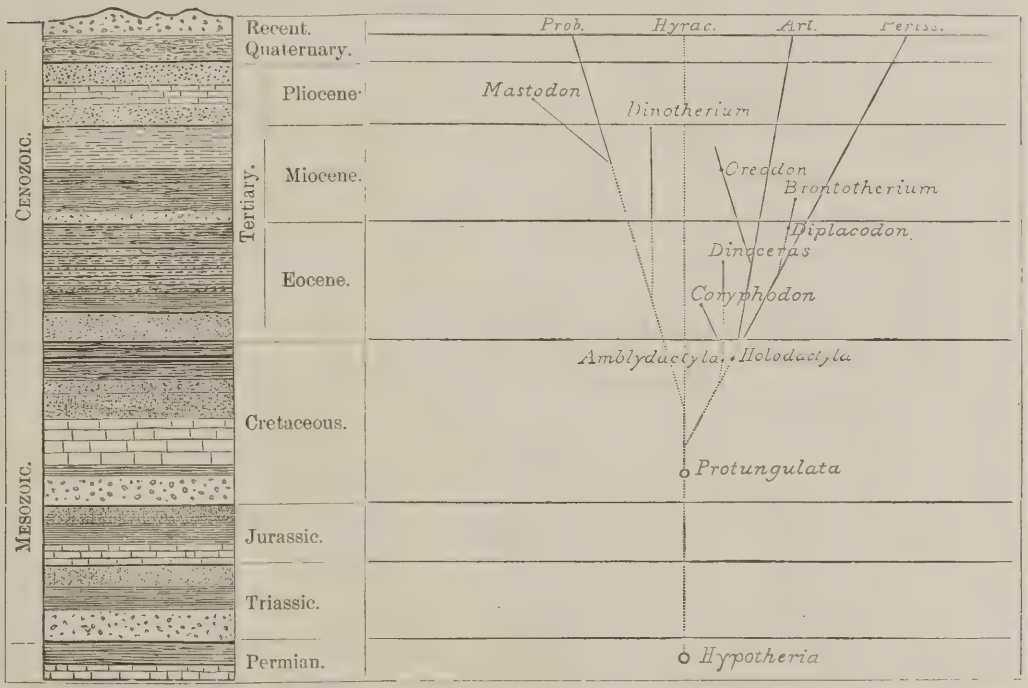


Figure 147.—Diagram to illustrate the genealogy of Ungulate Mammals.

A comparison of this diagram with the section on page 7 of this volume will make clear the special geological horizons of each group here referred to.

The *Hyracoidea* are represented by the existing *Hyrax*, and no fossil remains of the group are known. The principal characters of the order are as follows:

(1.) Brain, large and convoluted.
(2.) Canines, absent.
(3.) Incisor tusks.
(4.) Maxillo-turbinal bones.
(5.) Premolar and molar teeth, similar.
(6.) Malar bone articulating with lower jaw.
(7.) Alisphenoid canal.
(8.) Post-glenoid process.
(9.) Odontoid process, conical.
(10.) Cervical vertebræ, convexo-concave.
(11.) Trunk vertebræ, twenty-nine or more.
(12.) Scapula, spatulate.
(13.) Iliac bones, parallel.
(14.) Femur with third trochanter.
(15.) Femur and tibia not in line.
(16.) Ulna and fibula, complete.
(17.) Feet, plantigrade.
(18.) Axis of foot through third digit.
(19.) Carpals and tarsals not interlocking.
(20.) Central bone in carpus.
(21.) Three bones in first tarsal row.
(22.) Astragalus, grooved.

The Proboscidians, recent and extinct, may all be placed in a single order, with the following distinctive characters:

(1.) Brain, large and convoluted.
(2.) Canines, absent.
(3.) Incisor tusks.
(4.) Maxillo-turbinal bones, rudimentary.
(5.) Malar bone forming middle of zygomatic arch.
(6.) Post-glenoid process, absent.
(7.) Alisphenoid canal.
(8.) Odontoid process, conical.

(9.) Vertebræ, flat.
(10.) Scapula, acuminate.
(11.) Sternal bones, flat.
(12.) Iliac bones, transverse.
(13.) Femur and tibia in line.
(14.) Ulna and fibula, complete.
(15.) Femur without third trochanter
(16.) Feet, plantigrade.
(17.) Axis of foot through third digit.
(18.) Five digits in manus and pes.
(19.) Two bones in first tarsal row.
(20.) Carpals and tarsals, slightly interlocking.
(21.) Astragalus, flat.
(22.) Fibula articulating with calcaneum.

The *Holodactyla* were the direct ancestors of the great group to which both the Perissodactyls and Artiodactyls, living and extinct, belonged. The two latter form together a well marked order, which may be called the *Clinodactyla*. Their more important characters are as follows:

(1.) Brain, moderate in size, and convoluted.
(2.) Lower canines.
(3.) Maxillo-turbinal bones.
(4.) Malar bone forming front of zygomatic arch.
(5.) Post-glenoid process.
(6.) Cervical vertebræ, more or less convexo-concave.
(7.) Trunk vertebræ, not more than twenty-three.
(8.) Scapula, spatulate.
(9.) Iliac bones, parallel.
(10.) Femur and tibia not in line.
(11.) Feet, digitigrade.
(12.) Carpals and tarsals, strongly interlocking.
(13.) Central bone, absent.
(14.) Scaphoid articulating with magnum.
(15.) Astragalus, grooved.

Returning now to the *Amblydactyla*, or the group from which the *Dinocerata* were evidently derived, and to which they belong, we may safely assign to them general characters as follows:

(1.) Brain, small and smooth.
(2.) Teeth, not more than forty-four.
(3.) Post-glenoid process.
(4.) Odontoid process, conical.
(5.) Cervical vertebræ, flat.
(6.) Trunk vertebræ, twenty-three or more.
(7.) Scapula, acuminate.
(8.) Feet, plantigrade.
(9.) Five digits in manus and in pes.
(10.) Axis of foot through third digit.
(11.) Carpal and tarsal bones, somewhat interlocking.
(12.) Three bones in first tarsal row.
(13.) Astragalus, flat.
(14.) Fibula articulating with calcaneum.
(15.) Cuboid articulating with astragalus.

From this group came off, evidently in the late Cretaceous, first the *Coryphodontia*, having nearly all the above characters, and becoming extinct in the early Eocene. The *Dinocerata* probably branched off about the same time, and survived to the Middle Eocene, thus becoming much more specialized before their extinction.

Classification of Ungulates.

Accepting this general view of the origin of the Ungulates, living and extinct, their classification has been outlined in the diagram on page 173, and little more can now be done.

The attempts hitherto made to give a detailed classification of all the Mammalia, living and extinct, have signally failed, mainly because only a small part of even the extinct forms now known were included, and almost every new discovery tended to break down the definitions so systematically

recorded. The time for such an exhaustive classification has not yet arrived, and all that can be safely ventured upon in the present state of knowledge is to indicate the main groups, and their affinities, and await future discoveries.

Excluding the aberrant aquatic Sirenians, now regarded as of ungulate ancestry, and leaving out also *Toxodon* and other little known extinct forms, the Ungulate Mammals may then be arranged in natural groups, as follows:

CLASS MAMMALIA.

Sub-Class MONODELPHIA.

Super-Order UNGULATA.

(1.) Order Hyracoidea.

(2.) Order Proboscidea.

(3.) Order Amblydactyla { Dinocerata. Coryphodontia.

(4.) Order Clinodactyla { Mesaxonia (Perissodactyla). Paraxonia (Artiodactyla).

Before proceeding to discuss the relations of the *Dinocerata* to allied forms, it is important to first consider the relative value of the characters they share with these allies, and with groups still more remote.

The characters found in existing mammals, and, to a great extent, in the extinct forms from the Tertiary to the present time, are clearly of two kinds; general characters, derived from ancestral forms, and special characters, acquired in adaptation to their environment. Some of the latter may be negative characters, acquired by the disuse, or loss, of parts once advantageous.

The first series of characters are of most importance, as they indicate a genetic connection, perhaps remote, with the different groups that share them. Special characters, on the other hand, however closely they may correspond in different groups, do not necessarily indicate affinities, but may have been acquired by adaptation to peculiar surroundings, in groups quite distinct from each other.

These facts lie at the foundation of classification, and it is only by keeping the two series of characters separate, that the true relationship between different groups of animals can be made out, and their genealogy indicated with any probability.

Bearing this in mind in considering the *Dinocerata*, we must first seek to ascertain what general characters they have inherited from ancestral forms, and next what special characters they have since acquired. The relation of the group to the orders of existing Ungulates will then be indicated by ascertaining what characters, derived from a common ancestry, they share with each other, and what special characters, due, perhaps, to influences of similar nature, they possess in common.

We have seen that the primitive Mammals (*Hypotheria*) must have possessed a large number of general characters, some of which have already been given in the list on page 170. The primitive Ungulates (*Protungulata*), starting off on a particular line from the preceding type, would naturally retain nearly all these general characters, as indicated in the list on page 171. Each of the great branches that passed off from this parent stem retained a certain number of these primal characters, and some of them we find in the Ungulates of to-day.

The characters possessed by the *Holodactyla* were most of them still the ancestral features, and the *Amblydactyla*, on the line toward the *Dinocerata*, shared many of the same characters.

The *Dinocerata*, representing a further stage of progress, had still as their inheritance a number of persistent general characters. Some of these characters are the following:

(1.) Brain, small and smooth.
(2.) Orbit open behind.
(3.) Post-glenoid process.
(4.) Alisphenoid canal.
(5.) Vertebræ, flat.
(6.) Odontoid process, conical.
(7.) Sternum, flat.
(8.) Feet, plantigrade.

(9.) Five digits in manus and in pes.
(10.) Three bones in first tarsal row.
(11.) Astragalus, flat.

The specialized characters of the *Dinocerata*, acquired, doubtless, since this line separated from the *Protungulata*, are as follows:

(1.) Pre-nasal bones.
(2.) No upper incisors.
(3.) Canine tusks.
(4.) Skull surmounted with protuberances.
(5.) Condyle of lower jaw, posterior.
(6.) Pendent processes on lower jaw.
(7.) Iliac bones, transverse.
(8.) Femur and tibia in line.

If we now compare the *Dinocerata* with the *Coryphodontia*, we find they agree in the following characters:

(1.) Brain, small, and nearly smooth.
(2.) General form of teeth.
(3.) Temporal fossæ, widely separated.
(4.) Post-glenoid process.
(5.) Odontoid process, conical.
(6.) Vertebræ, flat.
(7.) Scapula, acuminate.
(8.) Feet, plantigrade.
(9.) Five digits in manus and in pes.
(10.) Axis of foot through third digit.
(11.) Three bones in first tarsal row.
(12.) Astragalus, flat.
(13.) Fibula articulating with calcaneum.
(14.) Cuboid articulating with astragalus.

In comparing the *Dinocerata* with living forms, and first with the Proboscidians, we find certain characters common to both, some of which at least, are general features, derived from a remote common ancestry. The more important of these characters are as follows:

(1.) Alisphenoid canal.
(2) Odontoid process, conical.
(3.) Vertebræ, flat.
(4.) Scapula, acuminate.
(5.) Sternal bones, flat.
(6.) Iliac bones, transverse.
(7.) Fibula, complete.
(8.) Femur and tibia in line.
(9.) Femur without third trochanter.
(10.) Five digits in manus and pes.
(11.) Axis of foot through third digit.
(12.) Fibula articulating with calcaneum.
(13.) Astragalus, flat.
(14.) Digits enclosed in a common integument.

The characters found in the *Dinocerata,* and not in the existing *Proboscidea* are more important, and more numerous. Among these characters are the following:

(1.) Brain, small and smooth.
(2.) No upper incisors.
(3.) Canine teeth above and below.
(4.) Anterior nares in front.
(5.) Pre-nasal bones.
(6.) Maxillo-turbinal bones, well developed.
(7.) Skull surmounted with protuberances.
(8.) Premaxillaries not meeting frontals.
(9.) Malar bone forming anterior part of zygomatic arch.
(10.) Post-glenoid process.
(11.) Condyle of lower jaw, posterior.
(12.) Neck of medium length.
(13.) Three bones in first tarsal row.
(14.) Astragalus articulating with cuboid.

If now we compare the *Dinocerata* with the Perissodactyls, we find an agreement in the following characters:

(1.) Premolar and molar teeth similar in form.
(2.) Nasal bones expanding posteriorly.
(3.) Malar bone forming front of zygomatic arch.
(4.) Alisphenoid canal.
(5) Posterior nares between last molars.
(6.) Post-glenoid process.
(7.) Carpal and tarsal bones, more or less interlocking.
(8.) Axis of foot through third digit.
(9.) Astragalus articulating with cuboid.

With the typical Artiodactyls, the *Dinocerata* have the following characters in common:

(1.) Cranial protuberances in pairs.
(2.) No upper incisors.
(3.) Premaxillary bones uniting with maxillaries and nasals.
(4.) Premaxillaries with palatine plates.
(5.) Lower incisors and canine in continuous series.
(6.) Sternal bones, flat.
(7.) Femur without third trochanter.
(8.) Carpal and tarsal bones, more or less interlocking.
(9.) Fibula articulating with calcaneum.
(10). Astragalus articulating with cuboid.

Modification of the Ungulate Foot.

The characters of most importance in Ungulate Mammals are found in the teeth, the brain, and the feet. The last are of special interest in the present connection, as they mark the stages of development in each group from the primitive Ungulates to the highly modified forms existing to-day. A brief statement of this development will make more clear the relation of the *Dinocerata* to other groups of Ungulates, with which we have already compared them.

The most generalized limbs in any vertebrates, above the class of fishes, are seen in some of the extinct aquatic reptiles, especially in forms allied to *Ichthyosaurus*. Here, as the author has shown,[1] we may find in one group,

(1.) Each limb a simple fin, or paddle,
(2.) Fore and hind limbs identical in structure,
(3.) Axis of limb through intermedial bone and third digit,
(4.) Single bone (humerus or femur) in propodial, or first, segment,
(5.) Three bones, including intermedial, in epipodial, or second, segment,
(6.) Mesopodial bones (carpals or tarsals) circular disks,
(7.) Number of digits six or more,
(8.) Metapodial bones and phalanges circular disks,
(9.) Phalanges, very numerous.

This is a primitive aquatic limb, flexible, but without joints, and adapted to swimming only. An example of such a limb is seen in figure 148, below.

For progression both in water and on wet ground, an essential modification of such a limb would be required, and a type seen in some of the living reptiles would gradually be developed. This limb would be jointed at two points, and have five digits, with the axis through the middle one. The foot in this limb would be very similar to the generalized foot of the primitive Mammal, and may here be taken as its representative. An example of such a foot is shown in figure 149.

In the true Ungulate Mammals, the modifications of the feet have undoubtedly taken place very nearly in the following manner:

(1.) The primitive Ungulates (*Protungulata*) must have had plantigrade, pentadactyl, feet, with the carpals and tarsals not interlocking, either with the metapodial bones, or with their own adjoining series. This would give a weak foot, adapted especially to progression in soft

[1] Limbs of Sauranodon, etc., American Journal of Science, 1880.

swampy ground. This type of foot would be somewhat like that represented in figure 149, below.

FIG. 148.

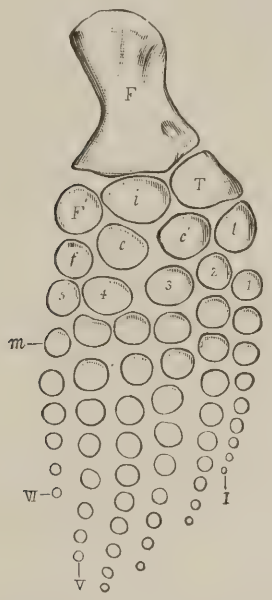


FIG. 149.

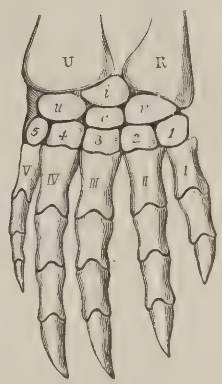


FIGURE 148.—Left hind limb of *Baptanodon discus*, Marsh; seen from below; one-eighth natural size.
FIGURE 149.—Right fore foot of *Chelydra serpentina*, Linnæus; front view (after Gegenbaur).

F. femur; F′. fibula; *i.* intermedium; *c.* central bone; *f.* fibulare; *m.* metatarsals; R. radius; *r.* radiale; T. tibia; *t.* tibiale; U. ulna; *u.* ulnare.

The Roman numerals denote the ordinal number of each digit present, counting from the inner side of the pentadactyl foot.

(2.) For locomotion on dry hard ground, a stronger foot was required, and a modification would soon take place, in the interlocking of the metapodials with the second row of carpals or tarsals that supported them. Examples of nearly this stage are seen in the fore feet of *Coryphodon* and *Dinoceras*, as shown in figures 150 and 152, below. The fore foot of the elephant (figure 156) will also serve to illustrate the same stage.

(3.) A still stronger foot was produced by the further interlocking of both the first and second row of carpals and tarsals, as well as the latter row with the metapodials below. This general type of foot belongs to the *Holodactyla*, and is seen also in some of the early Perissodactyls.

During these two stages of modification, or at a later period, a reduction in the number of digits in some forms also took place, evidently as a result of the same causes. As progression on dry land with the plantigrade five-toed foot began, the first digit, being the shortest of the series, soon left the ground, and was gradually lost.

Fig. 150.

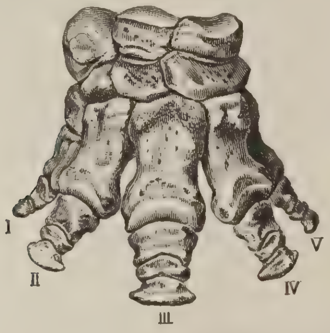


Fig. 151.

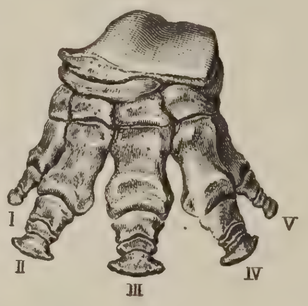


Figure 150.—Left fore foot of *Coryphodon hamatus*, Marsh, front view.
Figure 151.—Left hind foot of same.
Both figures are one-third natural size.

Fig. 152.

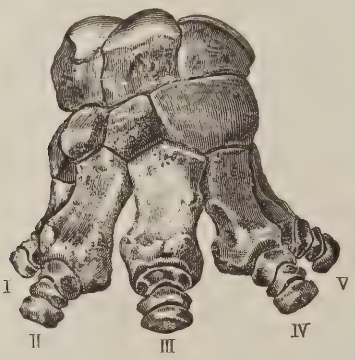


Fig. 153.

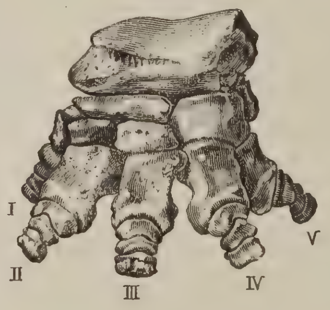


Figure 152.—Left fore foot of *Dinoceras mirabile*, Marsh.
Figure 153.—Left hind foot of same.
Both figures are one-fifth natural size.

The four remaining digits, having to do the work of five, were strengthened by the interlocking already mentioned, and also by coming nearer together.

(4.) In the next change that occurred, two kinds of reduction began. One leading to the existing Perissodactyl foot, and the other, apparently later, resulting in the Artiodactyl type. In the former, the axis of the foot remained in the middle of the third digit, as in the

pentadactyl foot. In the latter, it shifted to the outer side of this digit, or between the third and fourth toes. An example of the former is seen in the fore foot of *Brontotherium* and *Rhinoceros*, figures 158 and 160, below, while *Oreodon* and the hippopotamus, figures 162–165, show the latter type.

Fig. 154.

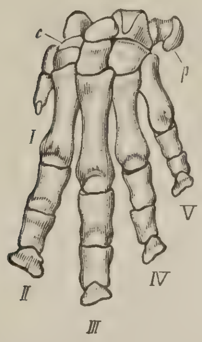


Fig. 155.

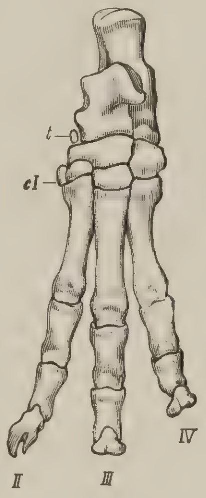


Figure 154.—Left fore foot of *Hyrax capensis*, Schrebr.
Figure 155.—Left hind foot of same.
c. central bone; *cI.* entocuneiform; *p.* pisiform; t. tibiale.
Both figures are natural size.

Fig. 156.

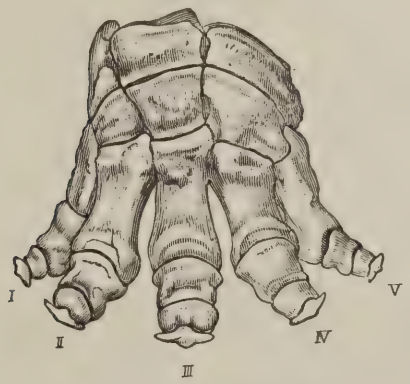


Fig. 157.

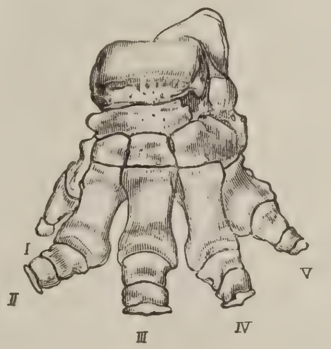


Figure 156.—Left fore foot of *Elephas Indicus*, Linnæus.
Figure 157.—Left hind foot of same.
Both figures are one-eighth natural size.

The position of the axis is the distinctive feature between these two types of feet, and not the number of toes, as the names usually applied to them indicate. In this respect, the terms Artiodactyl and Perissodactyl are misleading, and hence the names *Paraxonia* and *Mesaxonia* were proposed by the author, as substitutes, to express the true axial relation.

FIG. 158.

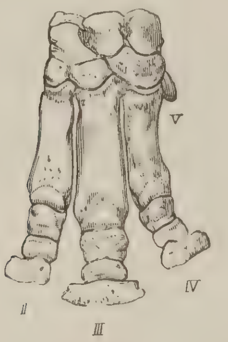


FIG. 159.

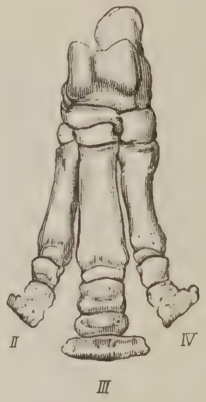


FIGURE 158.—Left fore foot of *Rhinoceros bicornis*, Linnæus.
FIGURE 159.—Left hind foot of same.
Both figures are one-eighth natural size.

FIG. 160.

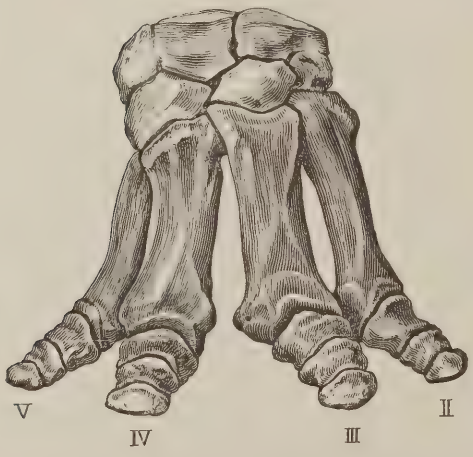


FIG. 161.

FIGURE 160.—Right fore foot of *Brontotherium ingens*, Marsh.
FIGURE 161.—Right hind foot of same.
Both figures are one-sixth natural size.

(5.) In the further reduction of the Perissodactyl foot, the fifth digit, being shorter than the remaining three, next left the ground, and

FIG. 162.

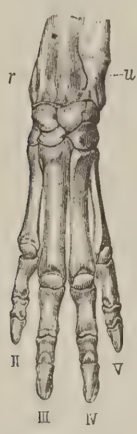


FIG. 163.

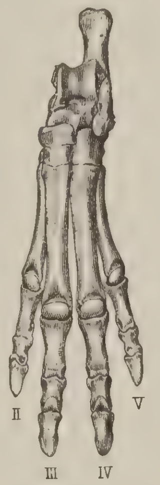


FIGURE 162.—Left fore foot of *Eporeodon socialis*, Marsh.
FIGURE 163.—Left hind foot of same.
Both figures are one-third natural size.

FIG. 164.

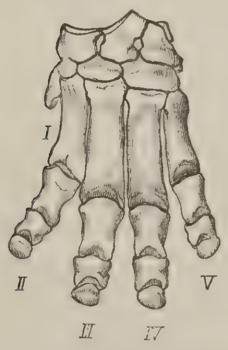


FIG. 165.

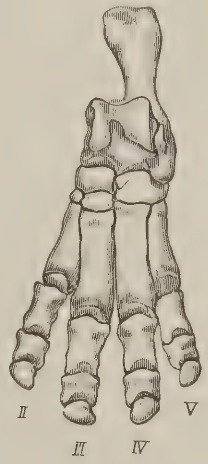


FIGURE 164.—Left fore foot of *Hippopotamus amphibius*, Linnæus.
FIGURE 165.—Left hind foot of same.
Both figures are one-eighth natural size.

gradually disappeared. Of the three remaining toes, the middle, or axial, one was the longest, and retaining its supremacy, as greater strength and speed were required, finally assumed the chief support of the foot, while

the outer digits left the ground, ceased to be of use, and were lost, except as splint bones. The foot of the existing horse (figures 166 and 167) shows the best example of this reduction in the Perissodactyls, as it is the most specialized known in the Ungulates.

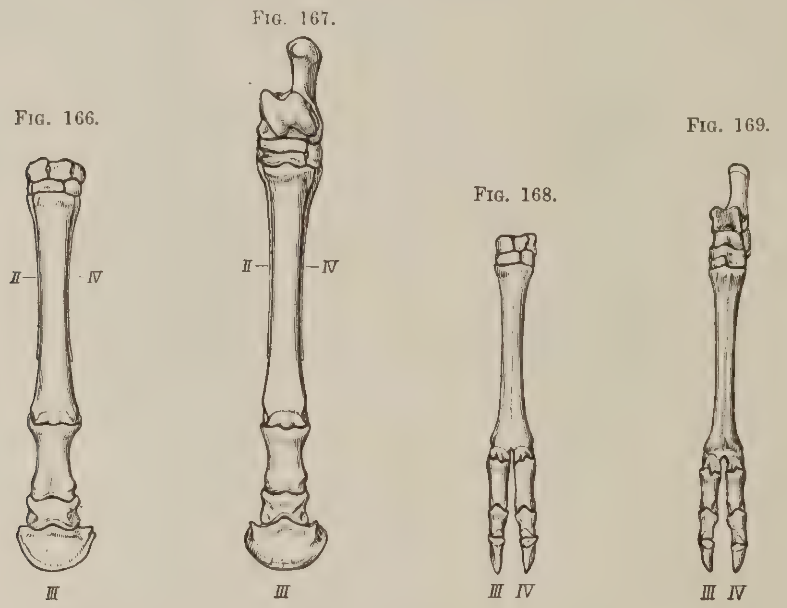


Figure 166.—Left fore foot of horse (*Equus caballus*, Linnæus).
Figure 167.—Left hind foot of same.
Both figures are one-eighth natural size.
Figure 168.—Left fore foot of goat (*Capra hircus*, Linnæus).
Figure 169.—Left hind foot of same.
Both figures are one-fifth natural size.

(6.) In the Artiodactyl foot, the reduction resulted in the gradual diminution of the two outer of the four remaining toes, the third and fourth doing all the work, and thus increasing in size and power. The fifth digit, for the same reasons as in the Perissodactyl foot, first left the ground, and became smaller. Next, the second soon followed, and these two gradually ceased to be functional, or were lost entirely, as in some of the Artiodactyls of to-day. The feet of the goat, figures 168 and 169, above, show this extreme reduction.

As the author has shown elsewhere, these reductions of the feet, and of the entire limbs, led to greater strength and speed, as the motion, before irregular, gradually came to act in a single plane.

The limb of the modern race-horse is a nearly perfect piece of machinery, especially adapted to great speed on dry, level, ground. The limb of an antelope, or deer, is likewise well fitted for rapid motion on a plain, but the foot itself is adapted to rough mountain work, as well, and it is to this advantage, in part, that the Artiodactyls owe their present supremacy.

The plantigrade, pentadactyl, foot of the primitive Ungulate, and even the Perissodactyl foot that succeeded it, both belong to the past humid period of the world's history. As the surface of the earth slowly dried up, in the gradual desiccation still in progress, new types of feet became a necessity, and the horse, antelope, and camel, were gradually developed, to meet the altered conditions.

The Proboscidians and Perissodactyls now living, except the horse, are doomed to early extinction, but the Artiodactyls, with their greater power of adaptation, will replace them, and perhaps develop new forms.

The genealogy of the special Ungulate lines which ended in the horse, tapir, and rhinoceros, of the Perissodactyls, and of the pig, camel, and deer, among the Artiodactyls, has already been marked out by the author elsewhere,[1] and need not here be repeated, especially as the subject will be fully discussed in a future volume.

Extinction of Large Mammals.

During the Mesozoic period, all the mammals appear to have been small, and it is not probable that any of large size existed, as reptilian life then reigned supreme. With the dawn of the Tertiary, a new era began, and mammalian life first found the conditions for its full and rapid development.

In the lower Eocene, the largest land mammal was *Coryphodon*, more than the equal, in size and power, of any of the reptiles of that time. *Dinoceras* and its allies, in the middle Eocene, were much larger, and were

[1] Introduction and Succession of Vertebrate Life in America, 1877. See also New Equine Mammals, etc., 1874, and Polydactyle Horses Recent and Extinct, 1879.

clearly the monarchs of the region in which they lived. In the upper Eocene, *Diplacodon*, about the size of the rhinoceros, was the largest mammal, but each of these three died out in the period in which it flourished.

At the base of the Miocene, the huge *Brontotheridæ*, nearly as large as the elephant, suddenly appear in great numbers. They remained for a short time the dominant land animals, and then became extinct.

The Proboscidians were the giants of the Pliocene, and hold the supremacy in size to-day, but are evidently a declining race, and must soon disappear.

The cause of the successive disappearance of each group of these large Tertiary mammals is not difficult to find. The small brain, highly specialized characters, and huge bulk, rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction. Smaller mammals, with larger brains, and more plastic structure, readily adapt themselves to their environment, and survive, or even send off new and vigorous lines.

The *Dinocerata*, with their very diminutive brain, fixed characters, and massive frames, flourished as long as the conditions were especially favorable, but, with the first geological change, they perished, and left no descendants.

Classification of Dinocerata.

The relations of the *Dinocerata* to other orders of mammals have now been fully considered in the preceding pages, and the main conclusions reached are given on pages 173 and 177. The generic sub-divisions of this group do not appear widely separated from each other, although at least three types, from successive geological horizons, can be distinguished. The species are numerous, and well marked, and there is strong evidence that many, if not all of them are from separate horizons. The differences due to age and sex are also manifest, and have been duly considered in estimating distinctive characters.

The *Dinocerata* now known may be placed in three genera: *Dinoceras*, *Tinoceras*, and *Uintatherium*. These may be separated by characters of the skull, vertebræ, and feet. There are also indications of several intermediate forms, which may, perhaps, be found to represent sub-genera, when additional specimens in good preservation are secured for comparison. Twenty-nine species may be distinguished, mainly by the skull alone, which, at present, offers the best distinctive characters.

Sub-order DINOCERATA, Marsh.

Family TINOCERATIDÆ, Marsh.

Uintatherium, Leidy.	*Dinoceras*, Marsh.	*Tinoceras*, Marsh.
Teeth, thirty-six.	Teeth, thirty-four.	Teeth, thirty-four.
Lower premolars, four.	Lower premolars, three.	Lower premolars, three.
Base of canine tusk, nearly vertical.	Base of canine tusk, nearly vertical.	Base of canine tusk, horizontal.
Parietal protuberance above post-glenoid process.	Parietal protuberance above post-glenoid process.	Parietal protuberance behind post-glenoid process.
Cervical vertebræ of moderate length.	Cervical vertebræ less elongate.	Cervical vertebræ short.
Lunar articulating with trapezoid?	Lunar articulating with trapezoid.	Lunar not articulating with trapezoid.

These three genera clearly represent three stages of development of the *Dinocerata*, and these stages correspond to the successive horizons of the middle Eocene in which the remains of these animals were entombed. *Uintatherium*, the most generalized type, is found at the lowest level; *Dinoceras* is from a somewhat higher stratum; and *Tinoceras*, the most specialized of all, occurs in the latest deposits.

In the Synopsis which follows this chapter, a systematic list of all the species of the *Dinocerata* is given in detail. In connection with the preceding pages, and the Plates at the end of the volume, this will place before the reader everything of importance now known in regard to the *Dinocerata*.

APPENDIX.

SYNOPSIS OF DINOCERATA.

The present synopsis contains a list of all the known species of the *Dinocerata*, and at least one characteristic figure of each species not elsewhere illustrated in this volume. Full references, also, are given to all the important literature. The complete titles of the works cited will be found in the Bibliography, which follows this synopsis. A brief history of the discovery of each specimen of importance, with the locality, geological horizon, collector, date, the nature of the remains, and where now preserved, is likewise placed on record under each species, as an essential part of a Monograph of the group.

The dates of publication of the various papers on the *Dinocerata* have been carefully reëxamined, and those here given are substantiated by conclusive evidence. The names adopted for genera and species are based on priority alone, except in the cases of those already used. For the higher groups, the new names proposed are to replace those previously applied, or to gain appropriate terms for nomenclature. *Amblydactyla* has thus been substituted for *Amblypoda*, and *Coryphodontia*, for *Pantodonta*, the names replaced being both essentially pre-occupied. The last term, moreover, has no significance when applied to the group of which *Coryphodon* is the original and characteristic type. The names *Protungulata*, *Holodactyla*, and *Clinodactyla*, express, respectively, a prominent feature of the groups they represent, and hence have been introduced in the preceding chapter.

DINOCERAS,[1] Marsh, 1872.

Dinoceras mirabile, Marsh.

(Plates I–VIII, XX–XLII, XLIV–LV.)

Woodcuts: 3, p. 13; 7, p. 15; 13, p. 19; 26, p. 26; 34, 35, p. 31; 39, 40, p. 38; 43, 44, 45, p. 42; 63, p. 61; 89, 90, p. 76; 91, 92, p. 77; 95, 96, p. 80; 99, 100, p. 82; 106, 107, p. 91; 108, 109, p. 94; 111, p. 98; 113, p. 103; 114, p. 105; 118, p. 108; 119, 120, p. 112; 121, 122, p. 115; 123, p. 119; 129, 130, 131, 132, p. 131; 133, p. 134; 137, 138, p. 141; 143, 144, p. 152; 145, 146, p. 154; 152, 153, p. 184.

Marsh, American Journal of Science and Arts (3), Vol. IV, p. 344, October, 1872; Vol. V, p. 119, Plates I and II, February, 1873; Vol. XI, p. 164, Plates II–IV, February, 1876; Vol. XXII, pp. 31, 32, Plate II, July, 1881.
American Naturalist, Vol. VII, p. 148, Plates I and II, March, 1873.
Proceedings of the American Philosophical Society, Vol. XII, p. 579, 1872; Vol. XIII, p. 256, 1873.
Fifth Annual Report of the U. S. Geological Survey, (figures from present volume, viz:) fig. 38, p. 256; 39, p. 257; 40, p. 258; 44, p. 260; 50, p. 263; 61, p. 268; 69, 70, p. 272; 76, 77, p. 275; 80, 81, 82, p. 278; 100, p. 289; 116, 117, p. 295; 120–123, p. 296; 134, 135, p. 301; 136, p. 302, 1884.
Garrod, Journal of Anatomy and Physiology, Vol. VII, pp. 267, 268, June, 1873.
The same, Complete Writings, pp. 121, 122, 1881.
Nature, Vol. VII (skull figured), p. 366, March 13, 1873.
Gaudry, Les Enchaînements du Monde Animal, p. 74, fig. 86, 1878.
Nicholson, Manual of Palæontology, Vol. II, pp. 370–373, figs. 656, 657, 1879.
Dana, Manual of Geology, 3d ed., Plate VII, figs. 1–4 (from present volume), 1880.
LeConte, Elements of Geology, pp. 525, 526, figs. 845, 845*a* (from present volume), 1882.
Flower, Encyclopædia Britannica, Vol. XV, p. 426, fig. 105, 1883.
Cope (Uintatherium mirabile).—Hayden's Report U. S. Geological Survey of the Territories for 1872, pp. 581, 584, 1873.
Proceedings of the Philadelphia Academy of Natural Sciences, Vol. XXV, p. 102, 1873.
Proceedings of the American Philosophical Society, Vol. XIII, pp. 61, 65, 1873.
Leidy (Uintatherium mirabile).—Extinct Vertebrate Fauna, pp. 97, 108, 332, 333, 1873.
Osborn (Uintatherium mirabile).—Memoir upon Loxolophodon and Uintatherium, pp. 24, 25, 1881.

The type specimen (number 1036) of this species was obtained in 1872 and 1873, by Messrs. B. D. Smith, J. W. Chew, and the author, from Big Bone Buttes, about twenty miles east-southeast of Fort Bridger, and twenty-five miles west of Green River, Wyoming.

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[1] *Δεινὸς*, terrible, and *κέρας*, a horn.

This specimen consists of a skull, complete except the lower jaws, cervical and lumbar vertebræ, ribs, pelvis, limb bones, etc.

Other specimens here referred to this species are as follows:

Number 1195, collected by Mr. J. W. Chew, near Sage Creek, about twelve miles southeast of Fort Bridger, and over thirty miles west of Green River, Wyoming, and consisting of bones of the fore leg and foot.

Number 1199, collected by Mr. F. S. Wicks, in 1873, near Henry's Fork, about ten miles below Lone Tree, and twenty miles west of Green River, Wyoming, consisting of bones of the feet, etc.

Number 1200, collected by the author, in August, 1873, at the Divide near Henry's Fork, nearly twenty miles southeast of Fort Bridger, and thirty miles west of Green River, Wyoming, consisting principally of carpal bones.

Number 1206, collected by Mr. O. Harger, in 1873, from the Divide west of Henry's Fork, and consisting of a radius, ulna, femur, etc.

Number 1208, collected by Mr. J. W. Chew and Mr. B. D. Smith, in 1873, near Sage Creek, about fifteen miles southeast of Fort Bridger, and nearly thirty-five west of Green River, Wyoming, and consisting of bones of the feet, etc.

Number 1210, obtained by Mr. J. W. Chew, November, 1874, in Wyoming, and consisting of sternum, femur, patella, tibia, feet bones, etc.

Number 1211, collected by Messrs. H. G. Cheney and H. A. Oaks, in August, 1873, at Old Hat Mountain, Henry's Fork, eighteen miles southeast of Fort Bridger, and about thirty-five west of Green River, Wyoming, and consisting of a fore foot, etc.

Number 1212, obtained by Messrs. S. Smith and J. W. Chew, November, 1873, near Sage Creek, Wyoming, and consisting of lower jaws, vertebræ, humerus, etc.

Number 1215, collected by Messrs. S. Smith and J. W. Chew, in 1873, at Cattail Springs, nearly thirty miles east-southeast of Fort Bridger, and about eighteen miles west of Green River, Wyoming, and consisting of a scapula, portions of the pelvis, etc.

Number 1218, collected by Messrs. S. Smith and S. Pearson, in October, 1875, about four miles below Lone Tree, on Henry's Fork, and twenty-five miles west of Green River, Wyoming, and consisting of a large part of a skeleton, especially bones of the feet and legs.

Number 1225, collected by Mr. J. W. Chew, near Henry's Fork, about twenty-five miles west of Green River, Wyoming, consisting of portions of the skull, vertebræ, bones of the feet, etc.

Number 1226, collected in 1873, by Messrs. S. Smith, J. W. Chew, and the author, at Big Bone Buttes, Wyoming, and consisting of portions of the skull, etc.

Number 1230, collected by Mr. E. S. Lane, in August, 1873, on the Divide west of Henry's Fork, Wyoming, and consisting of carpal bones.

Number 1232, collected by Mr. J. W. Chew, in 1874, in Wyoming, consisting of parts of a pelvis, and various limb bones.

Number 1234, collected by Mr. L. Lamotte, at Camp Springs, Wyoming, in 1873, consisting of limb bones, caudal vertebræ, etc.

Number 1245, collected in 1872, by Messrs. B. D. Smith and J. W. Chew, at Big Bone Buttes, Wyoming, and consisting of a humerus, etc.

Number 1247, collected in November, 1873, by Messrs. S. Smith and J. W. Chew, at Tule Springs, near Sage Creek, Wyoming, and consisting of tarsal bones, etc.

Number 1248, collected by Mr. B. D. Smith, in 1871, at Henry's Fork, Wyoming, and consisting of axis, femur, tibia, etc.

Number 1251, collected by Mr. J. Heisey, May, 1876, eight miles south of Dug Springs, near Haystack Mountain, about sixty-five miles east of Green River, and twenty-five miles south of the Union Pacific railroad, Wyoming, and consisting of vertebræ, etc.

Number 1252, collected by Mr. S. Smith, in February, 1875, north of Leavitt's Ranch on Henry's Fork about twenty miles west of Green River, Wyoming, consisting of parts of the skull, a tibia, fibula, etc.

Number 1255, collected in June, 1874, by Mr. L. Lamotte, at Big Bone Buttes, and consisting of part of the lower jaws, showing milk incisors in position, cervical and dorsal vertebræ, ribs, and limb bones, etc.

Number 1490, collected by Mr. L. Lamotte, in Wyoming, and consisting of incisor teeth.

Number 1514, collected by Mr. J. Heisey, May, 1876, eight miles south of Dug Springs, Wyoming, and consisting of lower jaws with molars.

Number 1520, collected by Dr. J. V. A. Carter, in Wyoming, consisting of fragments of a skull, carpal bones, vertebræ, etc.

Number 1528, collected by Mr. J. W. Chew, in 1875, near Henry's Fork, Wyoming, consisting mostly of tarsal bones.

Number 1529, collected in Wyoming, by an Indian, called Shoshone John, and consisting of a considerable number of bones from several different skeletons.

Number 1548, collected by Messrs. S. Smith and J. W. Chew, in November, 1873, near Sage Creek, Wyoming, consisting of a parietal horn-core, leg bones, etc.

The geological horizon of all these specimens is in the Dinoceras, or Bridger, beds of the Middle Eocene, as shown in the section on page 7.

The remains of the specimens here described are preserved in the Museum of Yale College.

Dinoceras agreste, Marsh, *n. s.*

Woodcut: 15, p. 19.

In this species, the nasals are separated in front by a distinct suture, extending back beyond the anterior projection of the premaxillary bone. They taper to a blunt conical point, which is much roughened, but presents no certain evidence of the attachment of prenasals.

The diastema behind the upper canine is nearly straight, and of moderate length (about 7 cm.), and, in this region, the palate is strongly vaulted. The palato-maxillary foramen is opposite the first premolar.

The posterior end of the malar bone was received into a shallow pit, in front of the glenoid cavity of the squamosal.

The occiput (figure 15, page 19) has the upper angles well rounded, and presents a median tubercle in the line of the vertical ridge. The foramen magnum is broad, and rises somewhat above the level of the condyles.

The type specimen (number 1221) of this species was discovered in 1873, by Mr. L. Lamotte, near Spanish John's Meadow, about thirty miles east-southeast of Fort Bridger, and fifteen miles west of Green River, Wyoming

This specimen consists of a skull, scapula, ribs, etc.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in the Yale College Museum.

Dinoceras cuneum, Marsh, *n. s.*

Woodcuts 93, 94, p. 77 ; 170, 171, below.

FIG. 170.

FIGURE 170.—Nasals of *Dinoceras cuneum*, Marsh (No. 1207).
a. side view ; *b.* top view ; *c.* front view.
One-fifth natural size.

The skull in this species tapers in front, but, in the type-specimen (number 1042), the nasal protuberances are not well preserved. The

maxillary protuberances are well developed, divergent, and connected by a moderate ridge. The top of the skull behind this is flattened, and separated from the lateral surface by a more or less prominent ridge, rising well on the front surface of the elevated parietal processes. These processes are over the post-glenoid processes. They are high, and, toward the apex, flattened antero-posteriorly, while they expand in transverse diameter. The ridge connecting them across the surface of the skull is present, but not elevated.

The foramen magnum is slightly higher than the occipital condyles. The palate is excavated in the region of the diastema.

Fig. 171.

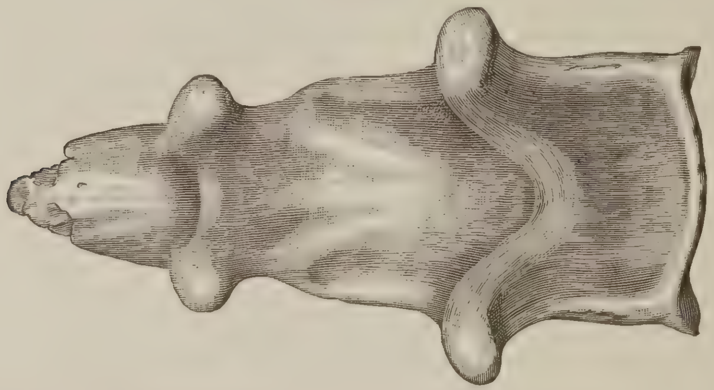

Figure 171.—Skull of *Dinoceras cuneum*, Marsh (No. 1042); seen from above. One-eighth natural size.

Another specimen (number 1207, figure 170) has the snout very tapering in front, and the nasal protuberances small, though rather prominent. The median suture is entirely obliterated, and the prenasals, if present, are thoroughly co-ossified with each other, and with the nasal bones.

The maxillary prominences are rounded, and not very divergent. The parietal protuberances are connected by a transverse ridge. The zygomatic process of the squamosal is not excavated for the posterior end of the malar.

The type specimen (number 1042) of this species was secured in May, 1875, by Messrs. S. Smith and J. Heisey, near Haystack Mountain, about sixty-five miles east of Green River, Wyoming.

The specimen consists of a skull, with a nearly complete series of dorso-lumbar vertebræ, sacrum, pelvis, etc.

The second specimen (number 1207), consisting of portions of the skull and vertebræ, was found by J. W. Chew and the author, in 1873, near Big Bone Buttes, Wyoming.

The geological horizon is in the Bridger beds of the Middle Eocene.

The only known specimens are in the Yale Museum.

Dinoceras distans, Marsh.

Woodcuts: 4, p. 13; 8, p. 15; 10, p. 16; 31, p. 29.

Marsh, Fifth Annual Report U. S. Geological Survey (figures from the present volume, viz :) fig. 41, p. 258; 45, p. 260; 66, p. 270, 1884.

The skull in the type specimen of this species (number 1235) has nearly the same general shape as in the type of *Dinoceras mirabile*, but is somewhat more robust, though pertaining to a young animal, as shown by the generally open sutures. The nasals taper in front, and bear a pair of low rounded oblique tubercles, much as in number 1036. They are terminated, as in that specimen, by flattened, nearly vertical, and deeply pitted, sutural surfaces, from which the prenasals have fallen away.

The maxillary elevations are stout and conical, and are connected across the median line of the skull by an elevated ridge. The naso-maxillary suture curves inward between the maxillary protuberances, and is strongly marked on their inner surfaces.

Behind the maxillary protuberances, the top of the skull is flattened, and presents two low oblique ridges, converging behind, along the lines of the fronto-nasal sutures. At the sides, the superior surface is separated from the lateral by a ridge, which rises nearly to the top of the parietal protuberances. These are well developed, triangular in section, and directed upward and outward, and are situated above the post-glenoid processes. The foramen magnum is below the upper margin of the occipital condyles.

In the type specimen, the post-glenoid process is robust. The zygomatic process of the squamosal is deeply excavated in front of the glenoid cavity, for the posterior end of the malar bone, which is peculiarly blunt, and rounded behind. The palato-maxillary foramen is rounded, and placed opposite the posterior half of the first premolar.

The cavity for the brain is exposed in this specimen, and shows a nasal septum just in front of the anterior constriction. The short olfactory lobes were bounded in front by thin cribriform plates.

The young specimen (number 1601) agrees with the type (number 1235) in the general shape of the skull, in the form of the maxillary protuberances and connecting ridge, in the shape and position of the parietal protuberances, and in the position of the palato-maxillary foramen. Also in the deep excavation for the end of the malar bone. The known differences may be attributed to age.

The type of this species (number 1235) was collected by Mr. S. Smith, in 1874, near Lone Tree, on Henry's Fork, Wyoming.

The second specimen (number 1601) was found by Mr. Smith in 1882, near Haystack Mountain, Wyoming.

The geological horizon of this species is in the Dinoceras beds.

The type specimen of this species is preserved in the Yale Museum.

Dinoceras laticeps, Marsh.

(Plates X–XIV, XLIII.)

Woodcuts: 14, p. 19; 22, p. 25; 27, p. 26; 33, p. 30; 47, p. 43; 50, p. 44; 57, 58, p. 54; and 112, p. 103; 136, p. 138; 139, 140, p. 149.

Marsh, American Journal of Science and Arts (3), Vol. VI, p. 301, October, 1873; Vol. XI, p. 164, Plate V, February, 1876.
Osborn and Speir (Uintatherium laticeps).—American Journal of Science and Arts (3), Vol. XVII, pp. 304, 305, 307, April, 1879.

The type of this species possesses the main characters of *Dinoceras*, but, in the premaxillaries, palate, and brain-cavity, shows an approach to *Tinoceras*, especially *Tinoceras pugnax*. It apparently represents a sub-genus of *Dinoceras*, which may be called *Paroceras*.

The type specimen of this species (number 1039) was obtained in August, 1873, by Mr. L. Lamotte and the author, near Spanish John's Meadow, Wyoming.

This specimen consists of a skull, lower jaws, vertebræ, etc.

A second specimen, a female (number 1202), consisting of a skull and other parts of the skeleton, was found by the author, in August, 1873, near Henry's Fork, about thirty miles west of Green River, Wyoming. Additional specimens are numbers 1197, 1222, 1239, and 1264.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are in Yale College Museum.

Dinoceras lucare, Marsh.

(Plate IX.)

Woodcuts: 46, p. 43; 103, 104, 105, p. 84; 110, p. 98; 172, 173, below.

Fig. 172.

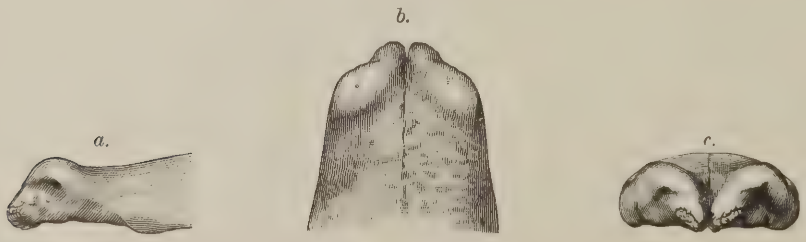

Figure 172.—Nasals of *Dinoceras lucare*, Marsh (No. 1038).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

FIG. 173.

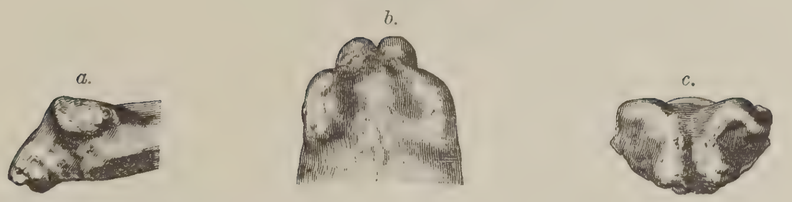

FIGURE 173.—Nasals of *Dinoceras lucare*, Marsh (No. 1568).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

Marsh, American Journal of Science and Arts (3), Vol. V, p. 408, May, 1873.
Fifth Annual Report of the U. S. Geol. Survey, (figures from the present volume, viz:) fig. 83, p. 279; 124, 125, p. 296, 1884.
Leidy (Uintatherium).—Extinct Vertebrate Fauna, p. 334, 1873.

The type specimen of this species (number 1038) was obtained by Messrs. B. D Smith, J. W. Chew and the author, two miles east of Big Bone Buttes, Wyoming, September, 1872, and September, 1873.

This specimen consists of a skull, and numerous parts of the skeleton.

The geological horizon of this species is in the Bridger Beds of the Middle Eocene.

The remains of this specimen are preserved in Yale College Museum.

Dinoceras reflexum, Marsh, *n. s.*

Woodcut: 174, below.

FIG. 174.

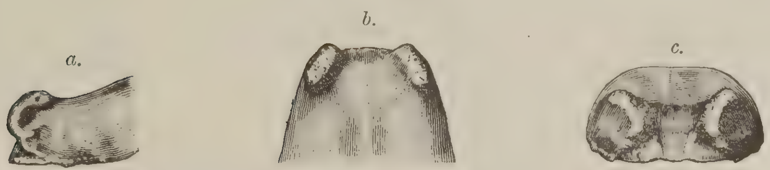

FIGURE 174.—Nasals of *Dinoceras reflexum*, Marsh (No. 1229).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

In the type of this species (number 1229), the nasal protuberances are small, but prominent, and are directed strongly upward. The nasal bones are completely united to the end, but are there terminated by sutural surfaces, looking nearly downward, and indicating the position of the prenasal bones, which have fallen away. The suture between the nasal and the premaxillary is evident, behind and below the nasal protuberance.

26

The post-glenoid process is large and strong, and the zygomatic process of the squamosal presents a pit for the end of the malar bone just in front of the glenoid cavity. The occipital crest shows a median keel on its posterior surface.

A cervical centrum, from which the epiphyses have nearly separated, shows that these vertebræ were proportionally shorter than in number 1255. The vertical diameter is to the longitudinal as 1 to .55, while in number 1255 these dimensions are about as 1 to .6.

A pyramidal bone, accompanying these specimens, has the face for the fifth metacarpal confluent with that for the unciform, as in figures 117 and 118, page 108, instead of distinct, as on Plate XXXII, figure 6.

The specimen (number 1229) upon which the species is based was collected in October, 1873, by Messrs. J. W. Chew and S. Smith, at Tule Springs, Wyoming.

This specimen consists of fragments of the skull, limb bones, etc.

The geological horizon of this species is in the Bridger beds of the Middle Eocene.

The known remains are preserved in Yale College Museum.

TINOCERAS,[1] Marsh, 1872.

Tinoceras anceps, Marsh.

Woodcuts: 97, 98, p. 80; 175, 176, 177, below.

FIG. 175.

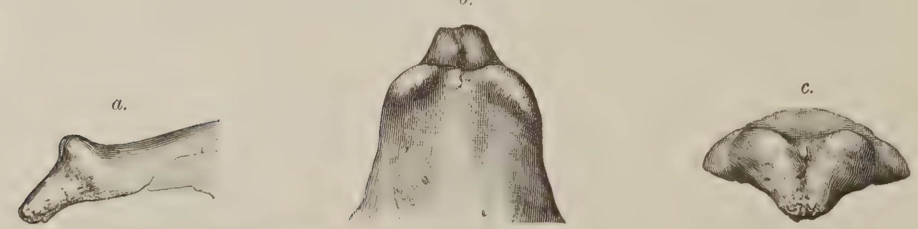

FIGURE 175.—Nasals of *Tinoceras anceps*, Marsh (No. 1266).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

Marsh (Titanotherium ? anceps.)—American Journal of Science and Arts (3), Vol. II, p. 35, July, 1871.

(Mastodon anceps.)—American Journal of Science and Arts, Vol. IV, p. 123, note, August, 1872.

(Tinoceras anceps.)—American Journal of Science and Arts (3), Vol. IV p. 322, October, 1872. (The name *Tinoceras* was published in advance, August 19, 1872, see Bibliography.) Vol. IV, p. 323, October, 1872; Vol. IV, p. 504, December, 1872; Vol. V, pp. 117, 122, February, 1873; Vol. V, p. 296, April, 1873.

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[1] *Τίνω,* to tear, and *κέρας,* horn.

FIG. 177.

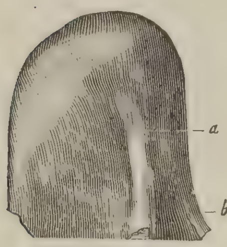

FIG. 176.

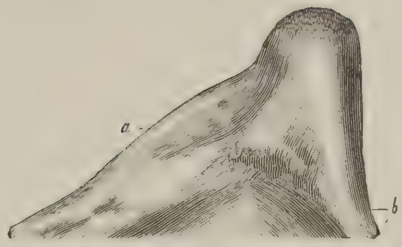

FIGURE 176.—Left parietal protuberance of *Tinoceras anceps*, Marsh (No. 1030); side view.
FIGURE 177.—The same specimen; front view.
a. anterior crest; *b.* posterior crest.
Both figures are one-half natural size.

Marsh, American Naturalist, Vol. VII, p. 52, January, 1873; pp. 147, 152, March, 1873; p. 218, April, 1873; Vol. VII, Appendix, p. viii, June, 1873.
Proceedings of the American Philosophical Society, Vol. XII, p. 578, for 1872, 1873; Vol. XIII, p. 256, 1873.
Cope (Uintatherium anceps.)—Proceedings of the American Philosophical Society, Vol. XIII, p. 61, 1873.

The type specimen of this species was of small size, and evidently a female. The occiput is elevated, and has a median vertical ridge. The lateral crests extend from the front nearly to the summit of the parietal protuberances. The latter are connected by a strong ridge passing directly over the brain-cavity. The post-glenoid processes are triangular in horizontal section, with the apex outward.

A second specimen (number 1266) has the nasal protuberances of moderate size, and resembling those of *Tinoceras grande*. The prenasal bones are firmly co-ossified with the nasals.

The type specimen (number 1030) was discovered by Lieut. W. N. Wann, in September, 1870, on the Divide near Sage Creek, fifteen miles southeast of Fort Bridger, Wyoming.

The remains of this specimen consist of portions of the skull, cervical and dorsal vertebræ, and a tibia.

The second specimen (number 1266) was found by Messrs. J. W. Chew and L. Lamotte, in August, 1874, in Wyoming. It consists of portions of a skull, and a few other bones.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in the Yale College Museum.

Tinoceras affine, Marsh, *n. s.*

Woodcuts: 16, p. 19; and 178, 179, below.

Fig. 178.

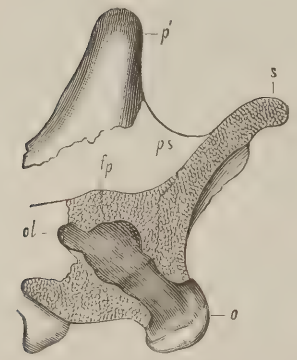

Fig. 179.

Figure 178.—Vertical section through cranium of *Tinoceras affine*, Marsh (No. 1574).
Figure 179.—The same specimen; seen from above.
ps. parietal supra-occipital suture; *fp.* fronto-parietal suture; *o.* occipital condyle; *ol.* olfactory lobes of brain; *p'.* parietal protuberance; *s.* supra-occipital crest.
Both figures are one-eighth natural size.

In the type of this species (number 1574), the snout tapers, and the nasals are divided by a distinct median suture.

The nasals are well preserved, and much resemble those of number 1041, but are more perfect. As in number 1040, they are thoroughly co-ossified to the extreme point, which is directed obliquely downward. The nasal protuberances are placed obliquely, and are flattened on their outer anterior surface. They are directed outward and upward, and are elongate-oval in section, the long axes of the ovals making about a right angle with each other in front of the snout.

The maxillary protuberances are elevated, but of moderate size, and are connected across by a rounded ridge. The parietal protuberances present a moderately sharp ridge on their anterior faces, and are somewhat club-shaped. They were connected across the top of the skull by a rounded ridge.

The foramen magnum is transversely oval, and rises nearly to the same height as the occipital condyles. The post-glenoid process is robust.

The occipital crest bears a rather prominent, but rounded, ridge along the median line, above the foramen magnum.

The palate is moderately excavated in front, and the palato-maxillary foramen is opposite the first premolar. The diastema is thick, strong, short, and straight. The vomer is preserved in this specimen, firmly lodged in a groove in the upper surface of the maxillaries

The face on the zygomatic process of the squamosal for the malar is broad and flat, and does not end in a pit, for the posterior end of the malar bone.

In this species, the brain occupies a very oblique position in the skull, as shown in the accompanying woodcut, figure 178. In the section of the cranium, the sutures defining the anterior and posterior limits of the parietal bones along the median plane of the skull are clearly shown. The fronto-parietal suture also (figure 178) is apparent on the superior surface of the skull, above the anterior part of the cavity for the cerebral hemispheres, as in *Dinoceras distans* (number 1601). The suture limiting the parietal posteriorly is evident in the same section. It is behind the cerebral cavity, but cannot be traced with certainty on the upper surface of the skull.

The type specimen (number 1574) of this species was obtained by Mr. J. Heisey, eight miles south of Dug Springs, Wyoming, in 1876.

This specimen consists of a skull, etc.

The geological horizon is in the Dinoceras beds of the Middle Eocene.

The only known remains of this specimen are in Yale College Museum.

Tinoceras annectens, Marsh.

Woodcuts: 6, p. 13; 21, p. 21; 36, 37, p. 36.

Marsh, Fifth Annual Report U. S. Geological Survey, (figures from the present volume, viz:) fig. 43, p. 258; fig. 56, p. 264; fig. 73, 74, p. 274, 1884.

The skull in the type of this species (number 1043) agrees generally in size and form, as far as preserved, with that of *Tinoceras ingens*, (number 1041). The canine tusk runs somewhat forward in number 1043, and the premaxillaries appear less robust. The palato-maxillary foramen is near the front premolar, not well in front of it, as in *Tinoceras ingens*. The upper canine (page 21, figure 21) has, on its outer side, a large, somewhat heart-shaped, worn surface.

The lower jaw in this species is slender, and bears a well developed process running downward and forward, and terminating in an oblique, nearly straight margin. The coronoid process is pointed.

The first dorsal in this specimen is proportionally shorter than in *Tinoceras anceps*, with the lateral faces for its ribs more approximate. The length of the floor of the neural canal is to the length of the under surface of the centrum as 3 to 4, and a similar proportion in the adjoining vertebra indicates an upward curvature in the neck at this point.

The type of this species (number 1043) was found by Mr. J. Heisey, in May, 1874, near Haystack Mountain, Wyoming.

The remains consist of a skull, and other portions of the skeleton.

The geological horizon is in the Bridger beds of the Middle Eocene.

The only known specimen of this species is in the Yale College Museum.

Tinoceras cornutum, Cope, sp.

Woodcuts: 180, 181, below.

FIG. 180.

FIGURE 180.—Skull of *Tinoceras cornutum*, Cope, sp.; side view.

This figure and the following were photographed on wood from Prof. Cope's original photographs, for which the author is indebted to the late Prof. Louis Agassiz. These photographs, although both marked $\frac{1}{6}$, are not of the same size. The present figures are copies, both reduced in the same proportion. The white portion at the base of the tusk is plaster, and the tooth is thus made to appear longer than in nature. The tusk itself belongs on the other side.

Fig. 181.

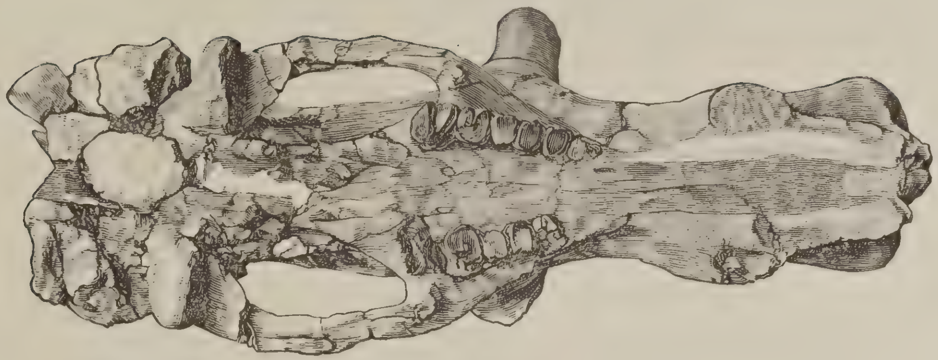

Figure 181.—Skull of *Tinoceras cornutum*, Cope, sp.; seen from below.
Both figures are about one-eighth natural size.

Cope (Lefalophodon dicornutus).—Proceedings of the American Philosophical Society, Vol. XII, p. 515, for 1872. 1873.

Telegram from Black Buttes, Wyoming, October, 1872.

The same, Palæontological Bulletin, No. 5, Second Edition, 1873.

(Eobasileus cornutus.)—Notices of new Vertebrates from the upper waters of Bitter Creek, Wyoming, November, 1872.

Proceedings of the American Philosophical Society, Vol. XII, p. 485, for 1872, 1873.

The same, Palæontological Bulletin, No. 6, 1873.

American Naturalist, Vol. VI, p. 774, December, 1872; Vol. VII, p. 49, January, 1873; Vol. VII, pp. 158, 159, March, 1873.

Hayden's Report of the U. S. Geological Survey for 1873, p. 457, 1874.

(Loxolophodon cornutus.)—Proceedings of the American Philosophical Society, Vol. XII, pp. 488 and 580, for 1872, 1873; Vol. XIII, pp. 45–54, Plates I–IV, 1873.

American Naturalist, Vol. VII, p. 291, Plates IV, V, May, 1873; Vol. XIII, p. 334, May, 1879; Vol. XVI, Plate XVII (Restoration), December, 1882.

Hayden's Report of the U. S. Geological Survey for 1872, pp. 568–575, Plates 1–4, 1873.

Osborn, Memoir upon Loxolophodon and Uintatherium, pp. 18, 20, 21, 27, 37, 44, 1881.

Osborn and Speir, American Journal of Science (3), Vol. XVII, pp. 304–309, Plate I, April, 1879.

Leidy (Uintatherium cornutum).—Extinct Vertebrate Fauna, pp. 333, 334, 1873.

Marsh (Tinoceras cornutus).—American Journal of Science and Arts (3), Vol. V, pp. 296, 311, April, 1873.

(Tinoceras grande.)—American Journal of Science and Arts (3), Vol. V, p. 294, April, 1873.

American Naturalist, Vol. VII, p. 217, April, 1873; Vol. VII, p. 306, May, 1873; Vol. VII, Appendix, p. ii, June, 1873.

Proceedings of the American Philosophical Society, Vol. XIII, p. 255, 1873.

In the restoration of this species as given by Professor Cope in the American Naturalist, Vol. XVI, Plate XVII, the skull used is the male one here figured, with the tusk much elongated. The lower jaw below it belonged to a female, possibly of another genus. The scapula, as restored, is unlike that of any of the known Dinocerata, and the entire fore limb is in a position anatomically impossible.

The type of the present species was obtained by Prof. E. D. Cope and Mr. S. Smith, in August, 1872, at Haystack Mountain, Wyoming.

The remains consist of portions of a skull, and other parts of the skeleton.

The skull as here figured is in the collection of Prof. Cope. Some other portions of the same skull and skeleton, subsequently collected by Mr. S. Smith, are in the Yale Museum.

Tinoceras crassifrons, Marsh.

Woodcuts: 30, p. 29; and 182, below.

Fig. 182.

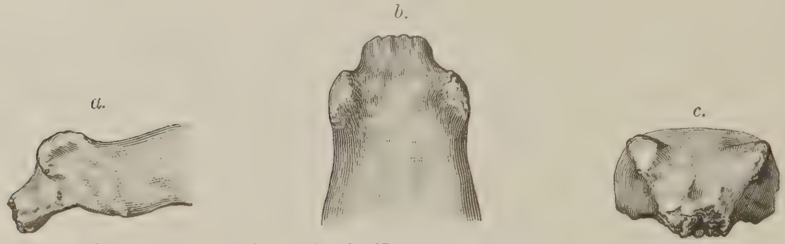

Figure 182.—Nasals of *Tinoceras crassifrons*, Marsh (No. 1236).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figure from the present volume, viz:) fig. 65, p. 270, 1884.

The nasals in the type of this species (number 1236) bear small, but prominent, tubercles, directed well upward and outward, and placed well back. In front of these elevations, the nasals are produced, and terminated by oblique, but nearly vertical, sutural surfaces for the pre-nasals.

The maxillary protuberances are high and prominent, and connected by a transverse, elevated, and sharp, ridge.

The upper surface of the skull is flattened, and well separated from the lateral surfaces by a ridge, gradually rising into the parietal protuberances. These protuberances are connected by a distinct transverse ridge, and are elevated, and, in section, somewhat triangular.

The olfactory lobes of the brain were short, and the olfactory chambers were not divided by a transverse bony septum.

The type specimen (number 1236) of this species was collected by Messrs. L. Lamotte and J. W. Chew, at Cattail Springs, about twenty-five miles southeast from Fort Bridger, and about eighteen miles west of Green River, Wyoming, July, 1874.

The remains of this specimen consist of various portions of a skull.
The geological horizon is in the Dinoceras beds of the Middle Eocene.
The known remains of this species are in the Museum at Yale College.

Tinoceras galeatum, Cope, sp.

Woodcuts: 183 and 184, below.

FIG. 184.

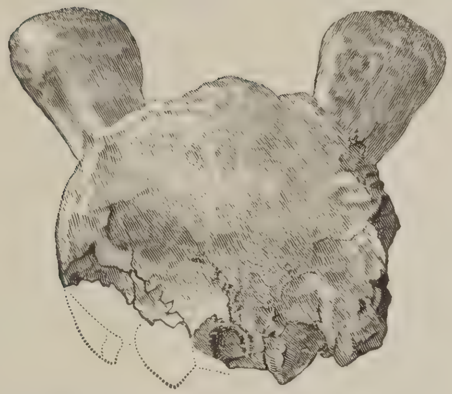

FIG. 183.

a.

b.

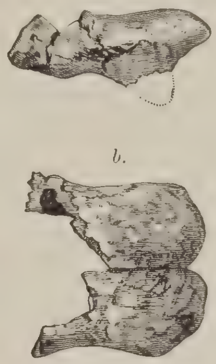

FIGURE 183.—Nasals of *Tinoceras galeatum* (after Cope); *a*. side view; *b*. top view.
FIGURE 184.—Posterior surface of same skull.
Both figures are one-eighth natural size.

These figures were photographed on wood from the lithographic plate, cited below.

Cope (Eobasileus galeatus).—Hayden's Report U. S. Geological Survey for 1873, pp. 456, 457, Plate I, 1874.
Proceedings of the American Philosophical Society, Vol. XIV, p. 17, 1874.
(Loxolophodon galeatus.)—Hayden's Report U. S. Geological Survey for 1873, Plate I, 1874.
Osborn, Memoir upon Loxolophodon and Uintatherium, pp. 21, 22, 1881.

The specimen upon which this species was based was obtained by Prof. E. D. Cope, in 1873, in the Bad Lands of South Bitter Creek, Wyoming.

The remains consist of various portions of the skull.

The geological horizon is in the Bridger beds of the Middle Eocene.

The known remains are preserved in Prof. Cope's collection.

Tinoceras grande, Marsh.

Woodcuts: 20, p. 21; 49, p. 44; 84, 85, 86, p. 71; 87, 88, p. 75; and 185, below.

FIG. 185.

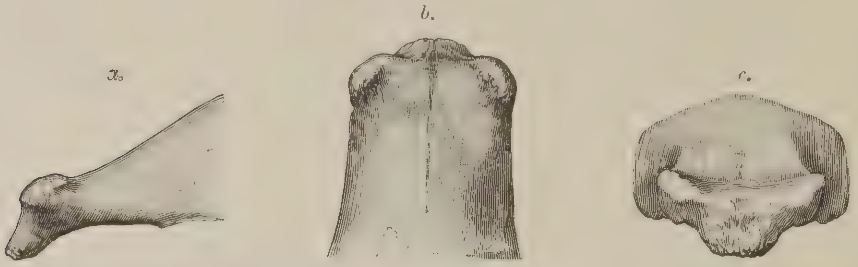

FIGURE 185.—Nasals of *Tinoceras grande*, Marsh (No. 1040).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

Marsh, American Journal of Science, Vol. IV, p. 323, October, 1872; Vol. V, pp. 295, 311, April, 1873.
American Naturalist, Vol. VII, p. 217, April, 1873.
Proceedings of the American Philosophical Society, Vol. XIII, p. 256, 1873.
Fifth Annual Report of the U. S. Geological Survey, (figures from the present volume, viz:) fig. 55, p. 264; 86, p. 280; 113, 114, 115, 118, 119, p. 295, 1884.
Cope, Proceedings of the American Philosophical Society, Vol. XIII, pp. 54, 61, 1873.
(Loxolophodon cornutus).—Hayden's Report U. S. Geological Survey for 1872, p. 575, 1873.

The type specimen (number 1040) of this species was collected at Barrel Springs, about seventy-five miles east of Green River, Wyoming, in 1872, by Messrs. J. W. Chew and B. D. Smith.

The remains of this specimen consist of portions of the skull, and cervical vertebræ.

The geological horizon of this species is in the Middle Eocene, in the Dinoceras beds.

The known remains are preserved in Yale College Museum.

Tinoceras hians, Marsh.

Woodcuts: 32, p. 30; and 186, below.

FIG. 186.

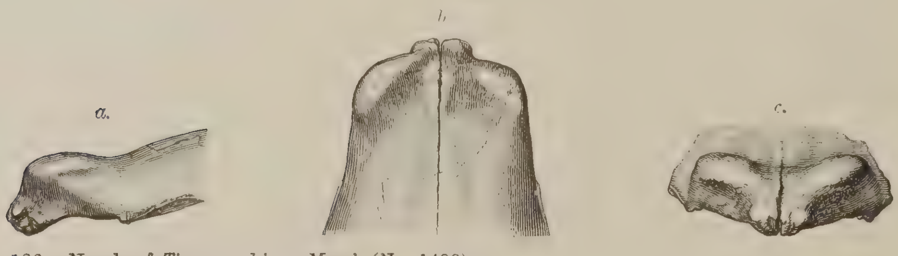

FIGURE 186.—Nasals of *Tinoceras hians*, Marsh (No. 1499).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

Marsh, Fifth Annual Report of the U. S. Geological Survey (figure from the present volume), fig. 67, p. 271, 1884.

The snout in the type of this species (number 1499) tapers in front, where the nasals are divided by persistent sutures, and bear low rounded tubercles. The maxillary protuberances are connected by a low rounded ridge. The upper surface of the skull behind these protuberances is flattened, and, in the region of the fronto-nasal sutures, elevated. It is separated from the lateral surface by a ridge, rising gradually upon the parietal protuberances, which are connected by a transverse elevation across the skull, above the brain case.

The olfactory chambers were divided transversely by a bony septum as shown in figure 32, page 30.

The palato-maxillary foramen extends back nearly to the middle of the second premolar. The premaxillaries are proportionally larger than in *Dinoceras laticeps* (number 1039), and straighter than in *Dinoceras mirabile* (number 1036). They present pits, as if for rudimentary teeth, as in number 1039.

This species is based upon a specimen (number 1499) collected in June, 1874, by Mr. L. Lamotte, at Cattail Springs, Wyoming.

The remains of this specimen consist of a skull, vertebræ, etc.

The geological horizon is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in the Museum of Yale College.

Tinoceras ingens, Marsh.

(Plates XV–XVIII, LVI.)

Woodcuts: 9, p. 16; 17, p. 19; 23, p. 25; 28, p. 27; 51, p. 45; 59, p. 55; 115, 116, p. 105; 117, p. 108; 124, p. 119; 134, 135, p. 136; 141, 142, p. 149.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figures from the present volume, viz:) figs. 46, p. 261; 52, p. 263; 58, p. 267; 63, p. 269; 88, p. 281; 96, 97, p. 286; 126, 127, p. 297; 137, p. 302, 1884.

The type specimen (number 1041) of this species was collected by Mr. S. Smith, near Haystack Mountain, Wyoming, in May, 1875.

This specimen consists of a skull, in excellent preservation.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are in Yale College Museum.

Tinoceras jugum, Marsh.

Woodcut: 187, below.

FIG. 187.

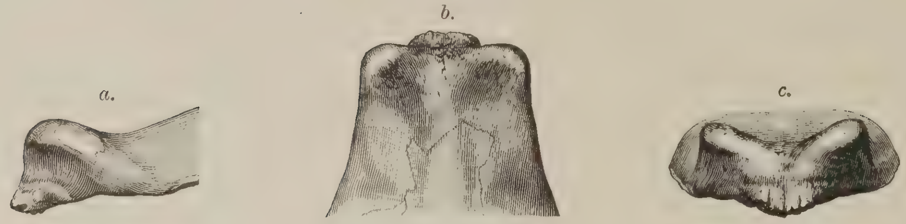

FIGURE 187.—Nasals of *Tinoceras jugum,* Marsh (No. 1500).
a. side view ; *b.* top view ; *c.* front view.
One-fifth natural size.

In this species, the snout tapers forward, and bears a pair of small flattened tubercles, directed well outward and forward. The nasals are thoroughly coössified, and project in front beyond the tubercles. The maxillary protuberances are high, and strongly divergent. They are connected by a high sharp ridge, which suggested the specific name.

The type of this species (number 1500) was found by Mr. L. Lamotte, in September, 1874, in Wyoming.

The specimen consists of portions of the skull, and fore limbs.

The geological horizon is in the Bridger beds of the Middle Eocene.

The only remains known are in the Yale Museum.

Tinoceras lacustre, Marsh.

Woodcut: 188, below.

FIG. 188.

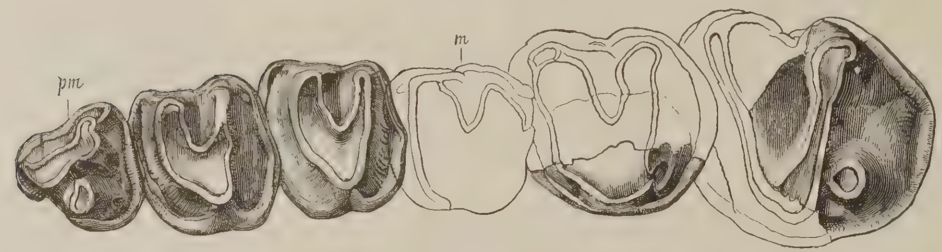

FIGURE 188.—Upper molars of *Tinoceras lacustre,* Marsh (No. 1037); seen from below.
m. first true molar; *pm.* first premolar.
Three-fourths natural size.

Marsh (Dinoceras lacustris).—American Journal of Science and Arts (3), Vol. IV, p. 344, October, 1872.

Proceedings of the American Philosophical Society, Vol. XIII, p. 256, 1873.

Cope (Uintatherium lacustre).—Hayden's Report U. S. Geological Survey for 1872, pp. 581, 584, 1873.

Proceedings of the American Philosophical Society, Vol. XIII, pp. 61, 66, 1873.

The type specimen (number 1037) of this species was discovered by Messrs. J. W. Chew and B. D. Smith, near Bitter Creek, Wyoming, in 1872.

This specimen consists of upper premolars, molars, and a radius.

The geological horizon is in the Bridger beds of the Middle Eocene.

The known remains of this species are preserved in the Museum of Yale College.

Tinoceras latum, Marsh, *n. s.*

Woodcuts: 189 and 190, below.

FIG. 189.

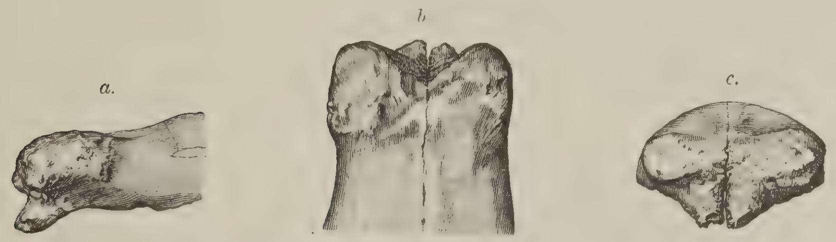

FIGURE 189.—Nasals of *Tinoceras latum*, Marsh (No. 1242).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

FIG. 190.

FIGURE 190.—Nasals of *Tinoceras latum*, Marsh (No. 1533).
a. side view; *b.* top view; *c.* front view.
One-fifth natural size.

The snout in the type specimen of this species tapers toward the end, but bears a pair of low rounded tubercles, directed nearly forward, and only slightly outward or upward. They are separated in front, along the median line, by an open suture between the nasal bones. These project forward beyond the protuberances, and terminate differently on the two sides, the left coming nearly to a point, while the right is a little shorter, and ends with an oblique sutural surface.

The skull presents a transverse ridge above the brain cavity, uniting the parietal protuberances.

The teeth preserved are but little worn, indicating a fully adult, but not old, animal.

Another specimen (number 1533) referred to this species is quite unlike any other in the collection in the form of the nasal bones so far as preserved, but, unfortunately, the specimen is considerably eroded. The snout, instead of tapering, expands forward, and presents on each side a broadly rounded, horizontal protuberance, scarcely rising at all above the general level of the nasal bones. They, also, project forward, far beyond the end of those bones, which were thoroughly consolidated, and directed somewhat downward, underneath the broad shelving protuberances.

The left maxillary protuberance preserved with this specimen is of large size, and flattened on its outer side.

This species, with *Tinoceras cornutum*, forms a distinct sub-genus of *Tinoceras*, which may be called *Platoceras.*

The type of this species (number 1242) was obtained in September, 1873, by Mr. L. Lamotte and the author, near Spanish John's Meadow, Wyoming.

The remains of this specimen consist of portions of the skull, and teeth.

A second specimen (number 1533), apparently a very old individual of the same species, was found in May, 1875, by Messrs. S. Smith and S. Pearson, at Haystack Mountain, Wyoming.

This specimen consists of portions of the skull. The extremity of the nasal bones is figured above.

The geological horizon of these specimens is in the Bridger beds.

The known remains of this species are preserved in Yale College Museum.

Tinoceras longiceps, Marsh.

Woodcuts: 38, p. 37; 48, p. 43; and 191, 192, below.

FIG. 191.

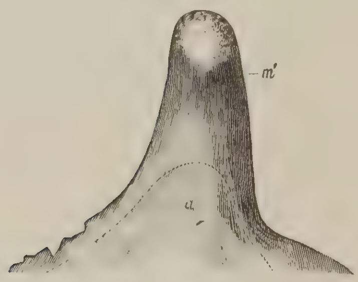

FIG. 192.

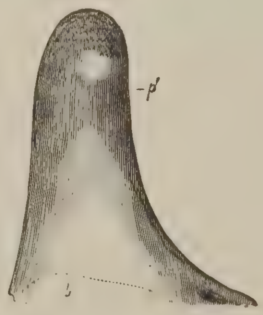

FIGURE 191.—Left maxillary protuberance of *Tinoceras longiceps*, Marsh (No. 1256, female); side view.
FIGURE 192.—Left parietal protuberance of same skull; side view.
The dotted line shows the outline of the cavities (*a* and *b*) at the base of each specimen.
Both figures are one-fourth natural size.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figures from the present volume, viz:) fig. 75, p. 275; 85, p. 279, 1884.

The skull in this species presents some striking peculiarities. The maxillary protuberances are placed well back, and are much above the socket for the weak and slender canine tooth (figure 48, page 43). They are directed upward and outward, and are greatly excavated within, and below, as shown in figure 191. The parietal protuberances are well developed, and are also excavated near the base. The anterior face, as far as preserved, shows no distinct indication of a sharp ridge rising on the frontal bone in front of the protuberance, as in *Dinoceras laticeps* (number 1202), but the parietal protuberances seem to have risen abruptly, as in *Tinoceras ingens*. They are flattened behind, but are scarcely expanded transversely, as in the males of this type. The zygomatic process of the squamosal is slender, and presents a decided pit for the posterior end of the malar, just in front of the glenoid cavity.

The lower jaw (figure 38, page 37) is elongated, and presents a small and weak pendent process, for the protection of the small and slender canine tusk (figure 48, page 43). This tusk has a nearly straight root, which suddenly contracts at the apex into a small orifice. The position of its socket is well in front of, and below, the maxillary horn-core, and unlike that of any other specimen in the Museum.

This species is based upon a specimen (number 1256, female) obtained by Mr. J. Heisey, at Red Dog Buttes, Wyoming, in June, 1876.

The remains of the type of this species consist of portions of the skull, lower jaws, etc.

The geological horizon is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are in Yale College Museum.

Tinoceras pugnax, Marsh.

(Plate XIX.)

Woodcuts: 5, p. 13; 18, p. 19; 19, p. 21; 24, p. 25; 29, p. 27; 52, p. 45; 67, p. 63.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figures from the present volume, viz:) fig. 42, p. 258; 53, p. 263; 54, p. 264; 59, p. 267; 64, p. 269; 89, p. 282; 104, p. 290, 1884.

The type specimen of this species (number 1044) was an individual of moderate size, and a male. The skull is short, and, seen from above strongly wedge-shaped. The nasal protuberances are small, high, and widely separated. The maxillary elevations are somewhat in front of the diastema. They are robust and recurved. The parietal protuberances are of moderate height, and transversely compressed at their summits. The premaxillaries are widely separated in front. The palato-maxillary foramen is opposite the second premolar. The posterior nares open upward through oval apertures, but little behind the bony palate. The

palate is much expanded between the canine tusks. The lower jaw has the alveoles of the incisors and canines nearly vertical. The flange for protection of the tusk is long, and rounded in front (Plate XIX, figure 1).

This specimen represents a distinct sub-genus of *Tinoceras*, which may be called *Laoceras*.

The type specimen (number 1044) of this species was found by Mr. S. Smith, May, 1875, at Haystack Mountain, Wyoming.

This specimen consists of a skull in good condition, and various other bones of the same individual.

The geological horizon of this specimen is in the Dinoceras beds.

The known remains of this species are preserved in the Museum of Yale College.

Tinoceras Speirianum, Osborn, sp.

Woodcut: 193, below.

FIG. 193.

FIGURE 193.—Skull of *Tinoceras Speirianum*, side view (after Osborn). One-eighth natural size.

Osborn (Loxolophodon Speirianum).—Memoir upon Loxolophodon and Uintatherium, pp. 18, 20, 21, 22, 24, 41, 44, Plate I, 1881.

This figure was photographed on wood from the lithographic plate cited above. The restorations of this skull do not allow some of its important features to be determined, but the generic characters are distinct.

In the restoration of this species, as given in the work cited above, the skull belonged to a male, and the lower jaw to a female. The bones of the fore limb, also, are in a position impossible in life.

The type specimen of this species was discovered by Mr. Francis Speir, in 1878, in Wyoming.

This specimen consists of the skull here figured.

The geological horizon is in the Bridger beds of the Middle Eocene.

The known remains of this species are in the Princeton Museum.

Tinoceras stenops, Marsh.

Woodcuts: 53, 54, p. 47; and 194, below.

FIG. 194.

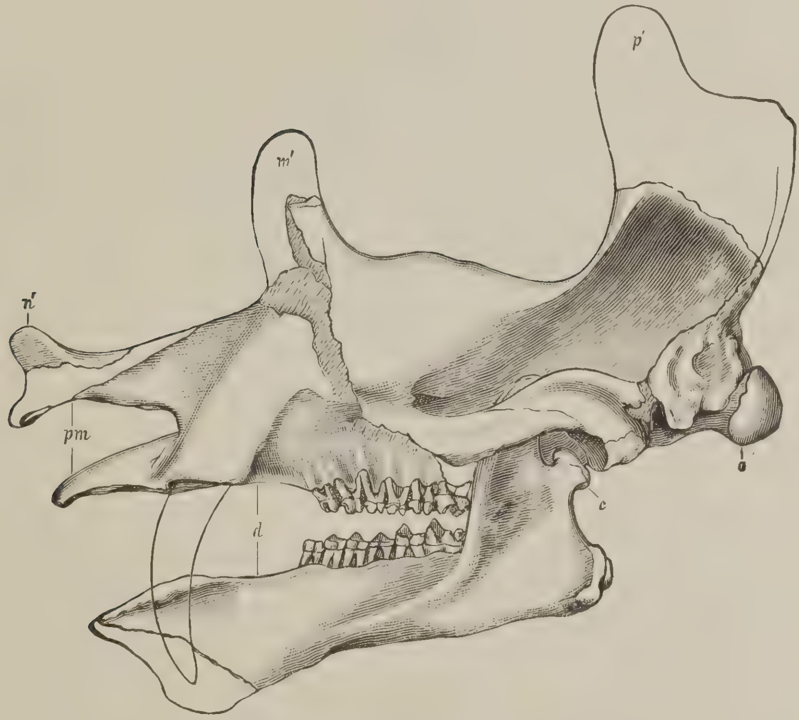

FIGURE 194.—Skull and lower jaw of *Tinoceras stenops*, Marsh (No. 1567).
c. condyle of lower jaw; *d*. diastema; *m'*. maxillary protuberance; *n'*. nasal protuberance; *o*. occipital condyle; *p'*. parietal protuberance; *pm*. premaxillary bone.
One-eighth natural size.

Marsh, Fifth Annual Report of the U. S. Geological Survey (figures from the present volume, viz:) figs. 90, 91, p. 283, 1884.

The skull in the type specimen of this species (number 1567) is narrow, and elongated. The nasal protuberances are flat below, and above. They appear to have been divergent, but of moderate size, though situated well forward. The maxillary protuberances were prominent, directed well forward, and connected by a transverse ridge. Behind them, on each side, stands a prominent protuberance over the orbit. Back of this, the superior and lateral surfaces of the skull pass into each other by regular curvature in front of the origin of the lateral ridges, which rise abruptly upon the parietal protuberances. These elevations are imperfectly preserved, but are flattened in front, and situated behind the post-glenoid processes.

The palate is excavated in the region of the diastema, and the palato-maxillary foramen is just in front of the first premolar, but not so far in front as in *Tinoceras ingens* (number 1041).

The lower jaw is slender, and expands rapidly in the region of the symphysis for the formation of the flanges protecting the canine tusks. When seen from above, the angle at which the rami meet at the symphysis is distinctly rounded in front, though somewhat less strongly than in *Dinoceras laticeps* (Plate XII, figure 1).

The type specimen (number 1567) of this species was collected by Mr. S. Smith, at Haystack Mountain, Wyoming, in May, 1882.

The remains of this specimen consist of a skull, with lower jaw, etc.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are in the Yale College Museum.

Tinoceras vagans, Marsh.

Woodcut: 12, p. 17.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figure from the present volume, viz:) fig. 49, p. 262, 1884.

The snout in the type of this species (number 1241) tapers somewhat in front, and the nasal protuberances are flattened and directed forward, outward, and upward. The nasal bones are united throughout. The maxillary protuberances are slender, but prominent, and united across by a low rounded ridge. The upper surface of the skull is separated from the lateral surface, above and behind the orbits, by a ridge, which rises upon the parietal protuberances. These are prominent, and are flattened antero-posteriorly. They were connected across the top of the skull by a low transverse elevation.

The type specimen (number 1241) of this species was discovered by Mr. S. Pearson, at Red Dog Buttes, Wyoming, in July, 1875.

This specimen consists of portions of the skull, etc.

The geological horizon is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in the Yale Museum.

UINTATHERIUM,[1] Leidy, 1872.

Uintatherium robustum, Leidy.

Woodcuts: 61, 62, p. 57; and 195, below.

FIG. 195.

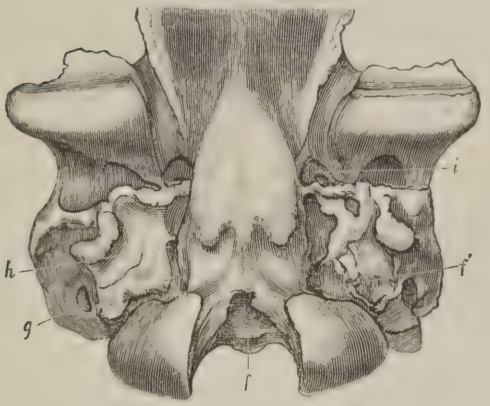

FIGURE 195.—Skull of *Uintatherium robustum*, Leidy (type specimen); bottom view of back part of skull. *f.* foramen magnum; *f'.* occipital foramen; *g.* stylo-mastoid foramen; *h.* foramen lacerum; *i.* vascular foramen in basisphenoid.

One-fourth natural size.

Leidy, Proceedings of the Philadelphia Academy of Natural Sciences, pp. 169, 241, 1872
American Journal of Science and Arts (3), Vol. IV, p. 240, September, 1872.
Extinct Vertebrate Fauna, pp. 93, 96, 333, 334, Plate XXV, Plate XXVI, figs. 1–8, Plate XXVII, figs. 30–34, 1873.
Cope, Proceedings of the Philadelphia Academy of Natural Sciences, p. 102, March, 1873; p. 295, for 1882, 1883.
Hayden's Report U. S. Geological Survey for 1872, pp. 581, 583, 1873.
American Naturalist, Vol. VII, p. 159, March, 1873; Vol. XVII, p. 68, January, 1883.
Proceedings of the American Philosophical Society, Vol. XIII, pp. 62, 64, 1873.
Marsh, American Journal of Science and Arts, Vol. V, p. 296, April, 1873.
American Naturalist, Vol. VII, p. 147, March, 1873.
Proceedings of the American Philosophical Society, Vol. XII, p. 578, 1872.
Osborn, Scott and Speir, Palæontological Report, 1877, pp. 62, 71, 82, 1878.
Osborn, Memoir upon Loxolophodon and Uintatherium, pp. 18, 28, 1881.
Leidy (Uintamastix atrox).—Extinct Vertebrate Fauna, pp. 94, 107, 333, 1873.

The type specimen of this species was collected in 1872, by Drs. J. V. A. Carter and J. K. Corson, fifty miles east of Fort Bridger, Wyoming.

The remains of this specimen consist of the cranial portion of a skull, with fragments of both jaws, and portions of limb bones.

The geological horizon of this species is in the Bridger beds of the Middle Eocene.

This type specimen is preserved in Prof. Leidy's collection.

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[1] *Uinta*, Indian name, and θηρίον, a wild beast.

Uintatherium fissidens, Cope, sp.

Woodcuts: 196 and 197, below.

FIG. 196. FIG. 197.

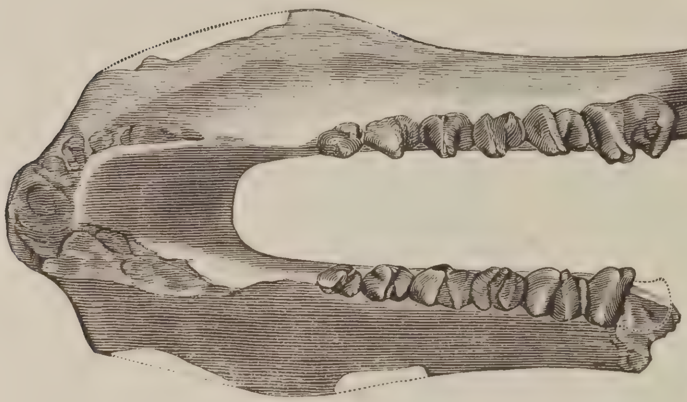

FIGURE 196.—Lower jaw of *Uintatherium fissidens* (after Cope); top view.
FIGURE 197.—The same specimen; front view.
Both figures are two-thirds natural size.

The above figures were made by a direct transfer from the original woodcuts cited below.

Cope (Bathyopsis fissidens).—Bulletin of the U. S. Geological Survey of the Territories, Vol. VI, No. 1, pp. 194–196, February, 1881.
Proceedings of the American Philosophical Society, Vol. XX, pp. 176, 177, 1882.
American Naturalist, Vol. XV, p. 75, January, 1881; Vol. XVIII, p. 1115, fig. 7, November, 1884.

The type specimen of this species was collected by Mr. J. L. Wortman, in 1880, in the Wind River Basin, Wyoming.

This specimen consists of portions of the lower jaws here figured.

The geological horizon of this species is not known with certainty, but is apparently in the Bridger beds of the Eocene.

The type specimen is preserved in Prof. Cope's collection.

Uintatherium latifrons, Marsh.

Woodcuts: 11, p. 17; 125, 126, 127, 128, p. 130.

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figure from the present volume, viz:) fig. 48, p. 262, 1884.

In this species, the snout tapers in front, where the nasals are divided by an open suture. The nasal protuberances are of moderate size, broadly oval at the base, approximate, and moderately divergent. The nasals project well forward beyond them. The maxillary protuberances are large, and rounded, and are connected by a very low transverse

ridge. The parietal protuberances were robust, and broadly oval in section near the top, and are connected by a low transverse ridge across the top of the skull. All these protuberances in this specimen are smooth, and regularly rounded.

The type specimen (number 1231) upon which this species is based was collected by Mr. J. W. Chew, in 1874, two miles from Big Bone Buttes, Wyoming.

The remains of this specimen consist of a skull, etc.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in Yale College Museum.

Uintatherium Leidianum, Osborn, Scott, and Speir.

Woodcut: 198, below.

FIG. 198.

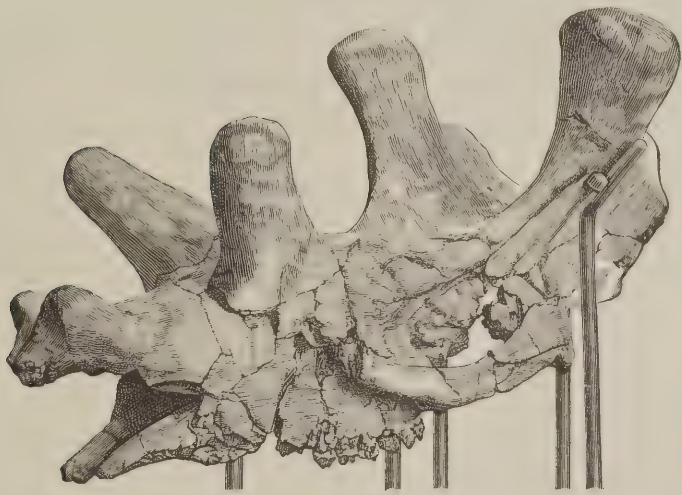

FIGURE 198.—Skull of *Uintatherium Leidianum* (after Osborn, Scott, and Speir); oblique side view. About one-eighth natural size.

This figure was photographed on wood from the original heliotype plate, cited below.

Osborn, Scott, and Speir, Palæontological Report, pp. 63–80, Plates VI–VIII, 1878.
Osborn, Memoir upon Loxolophodon and Uintatherium, pp. 18, 19, 22–24, Plate II, 1881.
Cope, American Naturalist, Vol. XVIII, p. 1117, fig. 10, November, 1884.

The type specimen of this species was collected in 1877, near Dry Creek, in Wyoming.

This specimen consists of a skull, and portions of the skeleton.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The type specimen is preserved in the Princeton Museum.

Uintatherium segne, Marsh.

Woodcuts: 41, 42, p. 39; 101, 102, p. 83; and 199, 200, below.

FIG. 199.

FIG. 200.

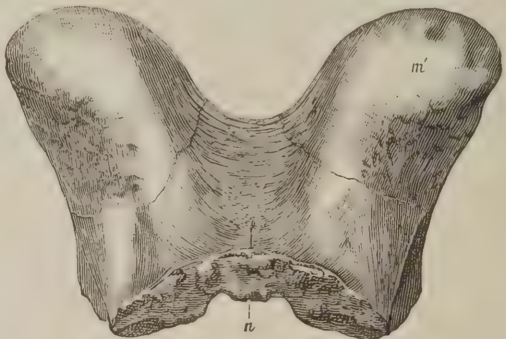

FIGURE 199.—Maxillary protuberances of *Uintatherium segne*, Marsh (No. 1194); seen from above.
FIGURE 200.—The same specimen; seen from in front.
m'. maxillary protuberance; n. nasal bone.
Both figures are one-fourth natural size

Marsh, Fifth Annual Report of the U. S. Geological Survey, (figures from the present volume, viz:) figs. 78, 79, p. 276, 1884.

The maxillary protuberances of the skull of this specimen are peculiar for their robust form. They are connected by a well developed transverse ridge. The parietal protuberances are massive, and somewhat club-shaped, and present a ridge in front, as in *Dinoceras mirabile* and *Tinoceras ingens*, evidently formed by the frontal bone rising nearly to the top of the protuberances.

The type specimen (number 1194) of this species was collected by Messrs. S. Smith and J. W. Chew, east of Fort Bridger, Wyoming, in October, 1873.

The remains of this species consist of a lower jaw, and other parts of the skeleton.

The geological horizon of this species is in the Dinoceras beds of the Middle Eocene.

The known remains of this species are preserved in Yale College Museum.

Amblypoda, see **Amblydactyla.**

Bathyopsis fissidens, see **Uintatherium fissidens.**

Dinocerea, see **Dinocerata.**

Dinoceras lacustris, see **Tinoceras lacustre.**

Eobasileus cornutus, see **Tinoceras cornutum.**

Eobasileus furcatus, see **Tinoceras.**

Eobasileus galeatus, see **Tinoceras galeatum.**

Eobasiliidæ, see **Tinoceratidæ.**

Lefalophodon bifurcatus, see **Tinoceras.**

Lefalophodon excressicornis, see **Tinoceras.**

Lefalophodon discornutus, see **Tinoceras cornutum.**

Loxolophodon anceps, see **Tinoceras anceps.**

Loxolophodon cornutus, see **Tinoceras cornutum.**

Loxolophodon furcatus, see **Tinoceras.**

Loxolophodon galeatus, see **Tinoceras galeatum.**

Loxolophodon grandis, see **Tinoceras grande.**

Loxolophodon pressicornis, see **Tinoceras.**

Loxolophodon Speirianum, see **Tinoceras Speirianum.**

Mastodon anceps, see **Tinoceras anceps.**

Pantodonta, see **Coryphodontia.**

Titanotherium? anceps, see **Tinoceras anceps.**

Uintamastix atrox, see **Uintatherium robustum.**

Uintatherium cornutum, see **Tinoceras cornutum.**

Uintatherium lacustre, see **Tinoceras lacustre.**

Uintatherium laticeps, see **Dinoceras laticeps.**

Uintatherium princeps, see **Uintatherium.**

Uintatherium lucare, see **Dinoceras lucare.**

Uintatherium mirabile, see **Dinoceras mirabile.**

Uintatheridæ, see **Tinoceratidæ.**

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First species of *Dinocerata* described (Titanotherium ? *anceps*). Titanotherium was the first generic name applied to any of the *Dinocerata*. It was then a synonym of *Menodus*, but having been once used in another group, it cannot be retained for any genus of the *Dinocerata*. The same well known rule excludes the name Loxolophodon, which was first given to a species of *Coryphodon*.

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First description of *Uintatherium robustum*.

Marsh, Othniel Charles.—Preliminary Description of New Tertiary Mammals; Parts I, II, III, and IV (from American Journal of Science and Arts, August and September, 1872), with Postscript and Errata, pp. 1–35; published in advance, August 19, 1872.

The genus *Tinoceras* proposed.

Marsh, Othniel Charles.—Note on *Tinoceras anceps.*—American Journal of Science and Arts (3), Vol. IV, p. 322. New Haven, October, 1872.
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Marsh, Othniel Charles.—Notice of a new Species of *Tinoceras.*—American Journal of Science and Arts (3), Vol. IV, p. 323. New Haven, October, 1873.
The same, published in advance, September 21, 1872.

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Marsh, Othniel Charles.—Notice of some Remarkable Fossil Mammals.—American Journal of Science and Arts (3), Vol. IV, pp. 343, 344. New Haven, October, 1872.
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Cope, Edward Drinker.—Notices of New Vertebrata from the Upper Waters of Bitter Creek, Wyoming Territory.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 483–486. Philadelphia, February, 1873.*
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* The authority for the date here assigned to this number of the Proceedings is the written statement of Prof. J. P. Lesley, Secretary of the Society, who then had charge of its publications.

Cope, Edward Drinker.—Second Notice of Extinct Vertebrates from Bitter Creek, Wyoming.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 487, 488. Philadelphia, February, 1873.
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Description of specimens named Loxolophodon cornutus, L. furcatus, and L. pressicornis. (See note on page 225 of the present volume.)

Cope, Edward Drinker.—Notice of Proboscidians from the Eocene of Southern Wyoming.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, p. 580. Philadelphia, February, 1873.

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Leidy, Joseph.—Remarks on Fossil Mammals from Wyoming.—Proceedings of the Academy of Natural Sciences, Vol. XXIV, pp. 240–242. Philadelphia, December, 1872.

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Marsh, Othniel Charles.—On some of Professor Cope's Recent Investigations.—American Naturalist, Vol. VII, pp. 51, 52. Salem, January, 1873.

Cope, Edward Drinker.—Proboscidians of the American Eocene, Correction.—American Naturalist, Vol. VII, p. 49. Salem, January, 1873.

Marsh, Othniel Charles.—On the Gigantic Fossil Mammals of the Order Dinocerata.—American Journal of Science and Arts (3), Vol. V, pp. 117–122, Plates I, II. New Haven, February, 1873.

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Cope, Edward Drinker.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, p. 515. Philadelphia, February, 1873.

Cope, Edward Drinker.—On the Dentition of Metalophodon.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 542–545. Philadelphia, February, 1873.

The name Loxolophodon stated to be a synonym of Bathmodon.

Marsh, Othniel Charles.—Communication on the Discovery of New Rocky Mountain Fossils.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 578, 579. Philadelphia, February, 1873.

A general statement of the characters of the *Dinocerata*.

The same.—Annales des Sciences Géologiques, vol. iii, pp. 99, 100, Paris, March, 1873.

Cope, Edward Drinker.—On the Short Footed Ungulata of Wyoming.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, for 1873, pp. 38–74, Plates I–IV. Philadelphia, 1873.

The same, published in advance, March, 1873.

Dinocerata considered a suborder of Proboscidea, with a list of species.

Cope, Edward Drinker.—Observations on the Structure and Systematic Position of the genus Eobasileus, Cope.—Proceedings of the Academy of Natural Sciences, Vol. XXV, pp. 10–12. Philadelphia, March, 1873.

The same, with changes, published in advance, 1873.

Eobasileus and allied genera referred to the Proboscidea.

Cope, Edward Drinker.—On the New Perissodactyles from the Bridger Eocene.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, for 1873, pp. 35, 36. Philadelphia, 1873.

The same, under the title—On Two New Perissodactyles from the Bridger Eocene.—Palæontological Bulletin No. 11. Philadelphia, 1873.

Marsh, Othniel Charles.—Note on the Dates of some of Professor Cope's recent Papers.—American Journal of Science and Arts (3), Vol. V, pp. 235, 236. New Haven, March, 1873.

Errors corrected in the dates of the Philosophical Society's meetings at which Prof. Cope's papers were claimed to have been read.

The same, American Naturalist, Vol. VII, p. 173. Salem, March, 1873.

Marsh, Othniel Charles.—The Fossil Mammals of the order Dinocerata.—American Naturalist, Vol. VII, pp. 146–153 ; Plates I–II. Salem, March, 1873.

Characters of the order *Dinocerata*, with list of errors in Prof. Cope's papers on the same subject, and figures of skull of *Dinoceras mirabile*.

Cope, Edward Drinker.—The Gigantic Mammals of the Genus Eobasileus.—American Naturalist, Vol. VII, pp. 157–160. Salem, March, 1873.

Description of Eobasileus, referring this form and *Uintatherium* to the Proboscidea.

Cope, Edward Drinker.—Table of Genera of Short Footed Ungulates of the American Eocene.—Proceedings of the Academy of Natural Sciences, Vol. XXV, pp. 102, 103. Philadelphia, March, 1873.

Cope, Edward Drinker.—The Eobasileus again.—American Naturalist, Vol. VII, p. 180. Salem, March, 1873.

A denial of errors charged in regard to the *Dinocerata*.

Marsh, Othniel Charles.—Additional Observations on the Dinocerata.—American Journal of Science and Arts, Vol. V, pp. 293–296. New Haven, April, 1873.

The same, published in advance, March 18, 1873.

A correction of errors in Prof. Cope's publications, with a list of the known species of *Dinocerata*.

Abstract of same.—Nature, vol. vii, p. 491, London, April 24, 1873.

Marsh, Othniel Charles.—Supplementary Note on the Dinocerata.—American Journal of Science and Arts (3), Vol. V, pp. 310, 311. New Haven, April, 1873.

The same, published in advance, March 22, 1873.

Errors in Prof. Cope's statements and plates pointed out, and names Loxolophodon and Eobasileus rejected.

Marsh, Othniel Charles.—On the Genus Tinoceras and its Allies.—American Naturalist, Vol. VII, pp. 217, 218. Salem, April, 1873.

Enumeration of errors in Prof. Cope's recent papers, and remarks upon photographs of *Tinoceras cornutum*.

Garrod, Alfred Henry.—On the Affinities of Dinoceras and its Allies.—Nature, Vol. VII, p. 481. London, April 24, 1873.

Dinocerata regarded as belonging to the Artiodactyla.

Cope, Edward Drinker.—On some of Professor Marsh's Criticisms.—American Naturalist, Vol. VII, pp. 290–299; Plates IV–V. Salem, May, 1873.

A denial of errors in description of Eobasileus, and in the dates of publications.

The same, with additions, Palæontological Bulletin, No. 13. Philadelphia, 1873.

Marsh, Othniel Charles.—On the dates of Professor Cope's Recent Publications.—American Naturalist, Vol. VII, pp. 303–306. Salem, May, 1873.

A protest against the authenticity of the dates claimed by Prof. Cope.

Marsh, Othniel Charles.—Tinoceras and its Allies.—American Naturalist, Vol. VII, pp. 306–308. Salem, May, 1873.

Correction of errors contained in Prof. Cope's recent papers.

Cope, Edward Drinker.—On the Tusk of Loxolophodon cornutus.—American Naturalist, Vol. VII, p. 315. Salem, May, 1873.

Marsh, Othniel Charles.—Notice of New Tertiary Mammals.—American Journal of Science and Arts (3), Vol. V, pp. 407–410. New Haven, May, 1873.

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Abstract of same.—Nature, vol. viii, p. 76, London, May 22, 1873.

Marsh, Othniel Charles.—Reply to Professor Cope's Explanation.—American Naturalist, Vol. VII, appendix, pp. i–ix. Salem, June, 1873.

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Marsh, Othniel Charles.—New Observations on the Dinocerata.—American Journal of Science and Arts (3), Vol. VI, pp. 300, 301. New Haven, October, 1873.

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The same, published in advance, September, 1873.

Marsh, Othniel Charles.—On the Gigantic Mammals of the American Eocene.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, pp. 255, 256. Philadelphia, 1873.

Leidy, Joseph.—Contributions to the Extinct Vertebrate Fauna of the Western Territories.—Report of the United States Geological Survey of the Territories, F. V. Hayden, 4to, Vol. I. Washington, 1873. (Dinocerata, pp. 93–109, 331–334; Plate XXV; Plate XXVI, figs. 1–8; Plate XXVII, figs. 30–34.)

A full discussion of the structure, classification, etc., of the *Dinocerata*.

On page 95 of this memoir, Dr. Leidy in citing the description of *Dinoceras mirabile* inadvertently omitted the following: "small, compressed, osseous elevations which probably supported a pair of horns. The maxillaries have a pair of." Prof. Cope, referring apparently not to the original paper, but to this incomplete passage, has since asserted that the author placed the posterior horn-cores of Dinoceras on the frontal bones, a statement without foundation.

Cope, Edward Drinker.—On the Extinct Vertebrata of the Eocene of Wyoming observed by the Expedition of 1872.—United States Geological Survey of the Territories, Sixth Annual Report, F. V. Hayden, 8vo, pp. 543–649, Plates I–VI. Washington, 1873.

Discussion of the *Dinocerata*, with descriptions of this author's species, and with figures of *Tinoceras cornutum*.

Cope, Edward Drinker.—Palæontological Bulletins Nos. 1–13, 8vo, Philadelphia, 1873.

Contains reproductions, among others, of the following papers, some with additions or corrections, viz:

No. 5.—Telegram from Black Buttes, Wyoming.

No. 6.—Notices of New Vertebrata from the Upper Waters of Bitter Creek, Wyoming Territory. Reprint.

No. 7.—Second Notice of Extinct Vertebrates from Bitter Creek, Wyoming. Reprint.

No. 11.—On two New Perissodactyles from the Bridger Eocene. With changes.

No. 13.—On some of Professor Marsh's Criticisms. With additions.

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Marsh, Othniel Charles.—Small Size of the Brain in Tertiary Mammals.—American Journal of Science and Arts (3), Vol. VIII, pp. 66, 67. New Haven, July, 1874.

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The same.—Annals and Magazine of Natural History (4), vol. xiv, p. 167, London, August, 1874.

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Cope, Edward Drinker.—Report on the Vertebrate Palæontology of Colorado.—Annual Report of the United States Geological and Geographical Survey of the Territories for 1873, F. V. Hayden, pp. 427–533, Plates I—VIII. Washington, 1874.

Description of Eobasileus galeatus, which, on Plate I, is called Loxolophodon galeatus.

Marsh, Othniel Charles.—On the Structure and Affinities of the Brontotheridæ.—American Journal of Science and Arts (3), Vol. VII, pp. 81–86, Plates I, II. New Haven, January, 1874.

Contains a comparison of the brain in *Brontotherium* and *Dinoceras*.

Abstract of the same.—Nature, vol. ix, p. 227, London, January 22, 1
The same.—American Naturalist, vol. viii, pp. 79–85, Salem, February, 1874.
Abstract of same.—Journal de Zoologie, vol. iii, pp. 61, 62, Paris, 1874.

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Marsh, Othniel Charles.—Ancient Lake basins of the Rocky Mountain Region.—American Journal of Science and Arts (3), Vol. IX, pp. 49–52. New Haven, January, 1875.

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Abstract of same.—American Naturalist, vol. ix, p. 119, Salem, February, 1875.
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Cope, Edward Drinker.—The Feet of Bathmodon.—Proceedings of the Academy of Natural Sciences, Vol. XXVII, p. 73. Philadelphia, May, 1875.

The *Dinocerata*, from the structure of the feet, regarded as a suborder.

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Marsh, Othniel Charles.—Principal Characters of the Dinocerata, Part I.—American Journal of Science and Arts (3), Vol. XI, pp. 163–168, Plates II–VI. New Haven, February, 1876.

Discussion of the order *Dinocerata*, with plates of the skull, brain-cast, lower jaw, and feet of *Dinoceras*.

Abstract of same.—Nature, vol. xiii, p. 374, London, March 9, 1876.
The same.—Journal de Zoologie, vol. v, pp. 136–145, Paris, 1876.
Abstract of same.—Zeitschrift für die gesammten Naturwissenschaften, vol. xiv, pp. 31, 32, Berlin, 1876.
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Owen, Richard.—On the existence or not of Horns in the Dinocerata.—American Journal of Science and Arts (3), Vol. XI, pp. 401–403. New Haven, May, 1876.

Doubts expressed as to the presence of true horns in the *Dinocerata*. (See page 167 of the present volume).

Marsh, Othniel Charles.—On some of the Characters of the genus Coryphodon, Owen.—American Journal of Science and Arts (3), Vol. XI, pp. 425–428. New Haven, May, 1876.

A comparison of the brain-cast in *Coryphodon* and *Dinoceras*.

Abstract of same.—Popular Science Review, p. 327, London, July, 1876.

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Flower, William Henry.—On the Extinct Animals of North America.—Popular Science Review, Vol. XV, pp. 276–298, Plate CXXXVIII. London, July, 1876.

Contains a brief description of the *Dinocerata*, with figures of skull and hind feet of *Dinoceras*.

Marsh, Othniel Charles.—Recent Discoveries of Extinct Animals.—American Journal of Science and Arts (3), Vol. XII, pp. 59–61. New Haven, July, 1876.

The same, American Naturalist, Vol. X, pp. 436–439. Boston, July, 1876.

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[Cope, Edward Drinker.]—The Lowest Mammalian Brain.—American Naturalist, Vol. XI, pp. 312–313. Boston, May, 1877.

Marsh, Othniel Charles.—Brain of Coryphodon.—American Naturalist, Vol. XI, p. 375. Boston, June, 1877.

Abstract of same.—Nature, vol. xvii, p. 340, London, February 28, 1878

Cope, Edward Drinker.—Brain of Coryphodon.—Proceedings of the American Philosophical Society, Vol. XVI, pp. 616–620, Plates I, II. Philadelphia, 1877.

Contains a comparison of brain-casts in *Coryphodon* and *Dinoceras*.

Marsh, Othniel Charles.—Principal Characters of the Coryphodontidæ.—American Journal of Science and Arts (3), Vol. XIV, pp. 81–85, Plate IV. New Haven, July, 1877.

A comparison of *Coryphodon* and *Dinoceras*, with figures of the feet in both.

The same.—Journal de Zoologie, vol. vi, pp. 380–385, Paris, 1877.

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Dinocerata here considered a suborder of the Amblypoda.

Marsh, Othniel Charles.—Introduction and Succession of Vertebrate Life in America.—An Address delivered before the American Association for the Advancement of Science, at Nashville, Tenn., August 30, 1877. Proceedings, Vol. XXVI, pp. 211–258, Salem, 1878.

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King, Clarence.—United States Geological and Geographical Exploration of the Fortieth Parallel, Vol. I, Systematic Geology, p. 403. 4to. Washington, 1878.

A partial list of the species of *Dinocerata* occurring in the Bridger beds of the Eocene.

Osborn, Henry Fairfield; Scott, William Berryman; Speir, Francis.—Palæontological Report of the Princeton Scientific Expedition of 1877; Contributions from the Museum of Geology and Archæology of Princeton College, No. 1, 8vo, pp. 146, Plate A, and I–X. New York, 1878.

Contains (pp. 62–82, Plates VI, VII) first descriptions of *Uintatherium Leidianum* and U. princeps, with figures.

Ryder, John A.—On the Mechanical Genesis of Tooth Forms.—Proceedings of the Academy of Natural Sciences for 1878, pp. 45–80. Philadelphia, April, 1878.

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Description of the lower jaw of a female *Tinoceras*, or allied genus.

Nicholson, Alleyne.—Manual of Palæontology, 8vo, Vol. II, p. 370–373, figs. 656, 657. Edinburgh and London, 1879.

Description of the *Dinocerata*, with figures of the skull and feet of *Dinoceras mirabile*, from the present volume.

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Garrod, Alfred Henry.—Dinocerata.—Journal of Anatomy and Physiology, VII, pp. 267–270. London and Cambridge, June, 1873.

The same, Complete Writings, edited by W. A. Forbes, 8vo, pp. 121–123. London, 1881.

Opinion that the *Dinocerata* belong to a family of the Artiodactyla.

Marsh, Othniel Charles.—Restoration of *Dinoceras mirabile.*—American Journal of Science (3), Vol. XXII, pp. 31, 32, Plate II. New Haven, July, 1881.

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First restoration of *Dinoceras mirabile*, new characters in the skull and sternum, and distinction stated between this genus and *Uintatherium.*

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Osborn, Henry Fairfield.—A Memoir upon Loxolophodon and Uintatherium (Two Genera of the Sub-Order Dinocerata).—Contributions from the E. M. Museum of Geology and Archæology of the College of New Jersey, Vol. I, No. 1, 4to, pp. 54, Plates I–IV. Princeton, 1881.

A general discussion of the *Dinocerata*, and first description of *Tinoceras Speirianum*, with a restoration. The statement on page 17 in regard to the discovery of the *Dinocerata* is erroneous, as the author was nearly two years earlier in the field than is there implied. See Introduction, page 2, of the present volume.

1882.

Cope, Edward Drinker.—Contributions to the History of the Vertebrata of the Lower Eocene of Wyoming and New Mexico, made during 1881.—Proceedings of the American Philosophical Society, number 111, for 1882, pp. 139–197. Philadelphia, 1882.

[Cope, Edward Drinker.]—American Naturalist, Vol. XVI, plate XVII, p. 1029. Philadelphia, December, 1882; Vol. XVII, Erratum.

A restoration of *Tinoceras cornutum*, without text.

LeConte, Joseph.—Elements of Geology, Second Edition, pp. 525, 526, figs. 845, 845*a*, 8vo. New York, 1882.

A brief description of *Dinoceras* and *Tinoceras*, with figures from the present volume.

Tomes, Charles Sissmore.—Dental Anatomy, Human and Comparative, 8vo, pp. 440. Second Edition, London, 1882. [*Dinocerata*, pp. 340–342, figure 146.]

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An extended abstract of the present volume, with 102 illustrations.

Cope, Edward Drinker.—The Amblypoda.—American Naturalist, Vol. XVIII, pp. 1110-1121, figs. 7, 8, 10. Philadelphia, November, 1884.

Contains figures of the lower jaw of *Uintatherium fissidens.*

POSTSCRIPT.

The Plates of the present volume, with their accompanying pages of explanations, were nearly all printed in 1881 and 1882, and the last of the series, in February, 1883. Most of the other illustrations, also, were completed by the latter date. In consequence of an unexpected delay in printing the text, some of the figures prepared for the Monograph first appeared elsewhere.

An extended abstract of this volume, with 102 illustrations, was prepared by the author, in July, 1884, for the Fifth Annual Report of the Director of the United States Geological Survey, and references to the pages of this Report will be found in the preceding Synopsis.

With the permission of the Director of the United States Geological Survey, an author's edition of 500 copies of this work was printed in February, 1885.

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First species of *Dinocerata* described (Titanotherium ? *anceps*). Titanotherium was the first generic name applied to any of the *Dinocerata*. It was then a synonym of *Menodus*, but having been once used in another group, it cannot be retained for any genus of the *Dinocerata*. The same well known rule excludes the name Loxolophodon, which was first given to a species of *Coryphodon*.

1872.

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The same, published in advance, August 1, 1872.

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First description of *Uintatherium robustum*.

Marsh, Othniel Charles.—Preliminary Description of New Tertiary Mammals; Parts I, II, III, and IV (from American Journal of Science and Arts, August and September, 1872), with Postscript and Errata, pp. 1–35; published in advance, August 19, 1872.

The genus *Tinoceras* proposed.

Marsh, Othniel Charles.—Note on *Tinoceras anceps.*—American Journal of Science and Arts (3), Vol. IV, p. 322. New Haven, October, 1872.
The same, published in advance August 24, 1872.
Abstract of same.—Popular Science Review, p. 94, London, January, 1873.

Marsh, Othniel Charles.—Errata.—American Journal of Science and Arts (3), Vol. IV, fourth page of cover, September, 1872. The same, p. 504. New Haven, December, 1872.

Marsh, Othniel Charles.—Notice of a new Species of *Tinoceras.*—American Journal of Science and Arts (3), Vol. IV, p. 323. New Haven, October, 1873.
The same, published in advance, September 21, 1872.

Description of *Tinoceras grande*, and family *Tinoceratidæ* proposed.

Marsh, Othniel Charles.—Notice of some Remarkable Fossil Mammals.—American Journal of Science and Arts (3), Vol. IV, pp. 343, 344. New Haven, October, 1872.
The same, published in advance, September 27, 1872.

Dinoceras mirabile and *D. lacustre* first described, and the order *Dinocerata* proposed.

Cope, Edward Drinker.—Notices of New Vertebrata from the Upper Waters of Bitter Creek, Wyoming Territory.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 483–486. Philadelphia, February, 1873.*
The same, published in advance. Philadelphia, 1872.

* The authority for the date here assigned to this number of the Proceedings is the written statement of Prof. J. P. Lesley, Secretary of the Society, who then had charge of its publications.

Cope, Edward Drinker.—Second Notice of Extinct Vertebrates from Bitter Creek, Wyoming.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 487, 488. Philadelphia, February, 1873.
The same, published in advance, 1872.

Description of specimens named Loxolophodon cornutus, L. furcatus, and L. pressicornis. (See note on page 225 of the present volume.)

Cope, Edward Drinker.—Notice of Proboscidians from the Eocene of Southern Wyoming.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, p. 580. Philadelphia, February, 1873.

The same, with errors, Telegram from Black Buttes, Wyoming, published in advance, 1872.

The same, Palæontological Bulletin, No. 5, re-published, Philadelphia, 1873.

Cope, Edward Drinker.—The Proboscidians of the American Eocene.—American Naturalist, Vol. VI, pp. 773, 774. Salem, December, 1872.

Leidy, Joseph.—Remarks on Fossil Mammals from Wyoming.—Proceedings of the Academy of Natural Sciences, Vol. XXIV, pp. 240–242. Philadelphia, December, 1872.

1873.

Marsh, Othniel Charles.—On some of Professor Cope's Recent Investigations.—American Naturalist, Vol. VII, pp. 51, 52. Salem, January, 1873.

Cope, Edward Drinker.—Proboscidians of the American Eocene, Correction.—American Naturalist, Vol. VII, p. 49. Salem, January, 1873.

Marsh, Othniel Charles.—On the Gigantic Fossil Mammals of the Order Dinocerata.—American Journal of Science and Arts (3), Vol. V, pp. 117–122, Plates I, II. New Haven, February, 1873.

The same, published in advance, January 28, 1873.

A general description of the *Dinocerata*, with figures of the skull of *Dinoceras*, and corrections of errors in Prof. Cope's publications on the same subject.

Abstract of same.—Zeitschrift für die Gesammten Naturwissenschaften, vol. vi, pp. 533, 534, Berlin, December, 1872.

The same.—Annales des Sciences Naturelles (Zoologie), vol. xvii, pp. 1–8, Paris, 1873.

The same.—Journal de Zoologie, vol. ii, pp. 160–168, Paris, 1873.

Abstract of same.—Geological Magazine, vol. x, pp. 115, 116, London, March, 1873.

Abstract of same, with figure of skull of *Dinoceras mirabilis.*—Nature, vol. vii, 366, London, March 13, 1873.

Abstract of same.—Popular Science Review, p. 213, London, April, 1873.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., pp. 334, 335, Stuttgart, 1875.

Cope, Edward Drinker.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, p. 515. Philadelphia, February, 1873.

Cope, Edward Drinker.—On the Dentition of Metalophodon.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 542–545. Philadelphia, February, 1873.

The name Loxolophodon stated to be a synonym of Bathmodon.

Marsh, Othniel Charles.—Communication on the Discovery of New Rocky Mountain Fossils.—Proceedings of the American Philosophical Society, Vol. XII, number 89, for 1872, pp. 578, 579. Philadelphia, February, 1873.

A general statement of the characters of the *Dinocerata*.

The same.—Annales des Sciences Géologiques, vol. iii, pp. 99, 100, Paris, March, 1873.

Cope, Edward Drinker.—On the Short Footed Ungulata of Wyoming.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, for 1873, pp. 38–74, Plates I–IV. Philadelphia, 1873.

The same, published in advance, March, 1873.

Dinocerata considered a suborder of Proboscidea, with a list of species.

Cope, Edward Drinker.—Observations on the Structure and Systematic Position of the genus Eobasileus, Cope.—Proceedings of the Academy of Natural Sciences, Vol. XXV, pp. 10–12. Philadelphia, March, 1873.

The same, with changes, published in advance, 1873.

Eobasileus and allied genera referred to tho Proboscidea.

Cope, Edward Drinker.—On the New Perissodactyles from the Bridger Eocene.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, for 1873, pp. 35, 36. Philadelphia, 1873.

The same, under the title—On Two New Perissodactyles from the Bridger Eocene.—Palæontological Bulletin No. 11. Philadelphia, 1873.

Marsh, Othniel Charles.—Note on the Dates of some of Professor Cope's recent Papers.—American Journal of Science and Arts (3), Vol. V, pp. 235, 236. New Haven, March, 1873.

Errors corrected in the dates of the Philosophical Society's meetings at which Prof. Cope's papers were claimed to have been read.

The same, American Naturalist, Vol. VII, p. 173. Salem, March, 1873.

Marsh, Othniel Charles.—The Fossil Mammals of the order Dinocerata.—American Naturalist, Vol. VII, pp. 146–153 ; Plates I–II. Salem, March, 1873.

Characters of the order *Dinocerata*, with list of errors in Prof. Cope's papers on the same subject, and figures of skull of *Dinoceras mirabile*.

Cope, Edward Drinker.—The Gigantic Mammals of the Genus Eobasileus.—American Naturalist, Vol. VII, pp. 157–160. Salem, March, 1873.

Description of Eobasileus, referring this form and *Uintatherium* to the Proboscidea.

Cope, Edward Drinker.—Table of Genera of Short Footed Ungulates of the American Eocene.—Proceedings of the Academy of Natural Sciences, Vol. XXV, pp. 102, 103. Philadelphia, March, 1873.

Cope, Edward Drinker.—The Eobasileus again.—American Naturalist, Vol. VII, p. 180. Salem, March, 1873.

A denial of errors charged in regard to the *Dinocerata*.

Marsh, Othniel Charles.—Additional Observations on the Dinocerata.—American Journal of Science and Arts, Vol. V, pp. 293–296. New Haven, April, 1873.
The same, published in advance, March 18, 1873.

A correction of errors in Prof. Cope's publications, with a list of the known species of *Dinocerata*.

Abstract of same.—Nature, vol. vii, p. 491, London, April 24, 1873.

Marsh, Othniel Charles.—Supplementary Note on the Dinocerata.—American Journal of Science and Arts (3), Vol. V, pp. 310, 311. New Haven, April, 1873.
The same, published in advance, March 22, 1873.

Errors in Prof. Cope's statements and plates pointed out, and names Loxolophodon and Eobasileus rejected.

Marsh, Othniel Charles.—On the Genus Tinoceras and its Allies.—American Naturalist, Vol. VII, pp. 217, 218. Salem, April, 1873.

Enumeration of errors in Prof. Cope's recent papers, and remarks upon photographs of *Tinoceras cornutum*.

Garrod, Alfred Henry.—On the Affinities of Dinoceras and its Allies.—Nature, Vol. VII, p. 481. London, April 24, 1873.

Dinocerata regarded as belonging to the Artiodactyla.

Cope, Edward Drinker.—On some of Professor Marsh's Criticisms.—American Naturalist, Vol. VII, pp. 290–299; Plates IV–V. Salem, May, 1873.

A denial of errors in description of Eobasileus, and in the dates of publications.

The same, with additions, Palæontological Bulletin, No. 13. Philadelphia, 1873.

Marsh, Othniel Charles.—On the dates of Professor Cope's Recent Publications.—American Naturalist, Vol. VII, pp. 303–306. Salem, May, 1873.

A protest against the authenticity of the dates claimed by Prof. Cope.

Marsh, Othniel Charles.—Tinoceras and its Allies.—American Naturalist, Vol. VII, pp. 306–308. Salem, May, 1873.

Correction of errors contained in Prof. Cope's recent papers.

Cope, Edward Drinker.—On the Tusk of Loxolophodon cornutus.—American Naturalist, Vol. VII, p. 315. Salem, May, 1873.

Marsh, Othniel Charles.—Notice of New Tertiary Mammals.—American Journal of Science and Arts (3), Vol. V, pp. 407–410. New Haven, May, 1873.

Definition of the genera *Tinoceras* and *Dinoceras*, with first description of *D. lucare.*

Abstract of same.—Nature, vol. viii, p. 76, London, May 22, 1873.

Marsh, Othniel Charles.—Reply to Professor Cope's Explanation.—American Naturalist, Vol. VII, appendix, pp. i–ix. Salem, June, 1873.

Statement in detail of the errors and incorrect dates of Prof. Cope's papers on the *Dinocerata.*

Marsh, Othniel Charles.—New Observations on the Dinocerata.—American Journal of Science and Arts (3), Vol. VI, pp. 300, 301. New Haven, October, 1873.

Additional characters of the order, and first description of *Dinoceras laticeps.*

The same, published in advance, September, 1873.

Marsh, Othniel Charles.—On the Gigantic Mammals of the American Eocene.—Proceedings of the American Philosophical Society, Vol. XIII, number 90, pp. 255, 256. Philadelphia, 1873.

Leidy, Joseph.—Contributions to the Extinct Vertebrate Fauna of the Western Territories.—Report of the United States Geological Survey of the Territories, F. V. Hayden, 4to, Vol. I. Washington, 1873. (Dinocerata, pp. 93–109, 331–334; Plate XXV; Plate XXVI, figs. 1–8; Plate XXVII, figs. 30–34.)

A full discussion of the structure, classification, etc., of the *Dinocerata.*

On page 95 of this memoir, Dr. Leidy in citing the description of *Dinoceras mirabile* inadvertently omitted the following: "small, compressed, osseous elevations which probably supported a pair of horns. The maxillaries have a pair of." Prof. Cope, referring apparently not to the original paper, but to this incomplete passage, has since asserted that the author placed the posterior horn-cores of Dinoceras on the frontal bones, a statement without foundation.

Cope, Edward Drinker.—On the Extinct Vertebrata of the Eocene of Wyoming observed by the Expedition of 1872.—United States Geological Survey of the Territories, Sixth Annual Report, F. V. Hayden, 8vo, pp. 543–649, Plates I–VI. Washington, 1873.

Discussion of the *Dinocerata,* with descriptions of this author's species, and with figures of *Tinoceras cornutum.*

Cope, Edward Drinker.—Palæontological Bulletins Nos. 1–13, 8vo, Philadelphia, 1873.

Contains reproductions, among others, of the following papers, some with additions or corrections, viz:

No. 5.—Telegram from Black Buttes, Wyoming.

No. 6.—Notices of New Vertebrata from the Upper Waters of Bitter Creek, Wyoming Territory. Reprint.

No. 7.—Second Notice of Extinct Vertebrates from Bitter Creek, Wyoming. Reprint.

No. 11.—On two New Perissodactyles from the Bridger Eocene. With changes.

No. 13.—On some of Professor Marsh's Criticisms. With additions.

1874.

Marsh, Othniel Charles.—Small Size of the Brain in Tertiary Mammals.—American Journal of Science and Arts (3), Vol. VIII, pp. 66, 67. New Haven, July, 1874.

The same, published in advance, 1874.

The same.—American Naturalist, vol. viii, pp. 503, 504, Salem, August, 1874.

The same.—Annals and Magazine of Natural History (4), vol. xiv, p. 167, London, August, 1874.

Abstract of same.—Nature, vol. x, p. 273, London, August 6, 1874.

The same.—Journal de Zoologie, vol. iii, pp. 326, 327, Paris, 1874.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., p. 772, Stuttgart, 1874.

Cope, Edward Drinker.—Report on the Vertebrate Palæontology of Colorado.—Annual Report of the United States Geological and Geographical Survey of the Territories for 1873, F. V. Hayden, pp. 427–533, Plates I—VIII. Washington, 1874.

Description of Eobasileus galeatus, which, on Plate I, is called Loxolophodon galeatus.

Marsh, Othniel Charles.—On the Structure and Affinities of the Brontotheridæ.—American Journal of Science and Arts (3), Vol. VII, pp. 81–86, Plates I, II. New Haven, January, 1874.

Contains a comparison of the brain in *Brontotherium* and *Dinoceras*.

Abstract of the same.—Nature, vol. ix, p. 227, London, January 22, 1

The same.—American Naturalist, vol. viii, pp. 79–85, Salem, February, 1874.

Abstract of same.—Journal de Zoologie, vol. iii, pp. 61, 62, Paris, 1874.

1875.

Marsh, Othniel Charles.—Ancient Lake basins of the Rocky Mountain Region.—American Journal of Science and Arts (3), Vol. IX, pp. 49–52. New Haven, January, 1875.

Contains a description of the Eocene Lake-basin in which the *Dinocerata* are found.

Abstract of same.—American Naturalist, vol. ix, p. 119, Salem, February, 1875.

Abstract of same.—Geological Magazine (2), vol. ii, pp. 232, 233, London, May, 1875.

Cope, Edward Drinker.—The Feet of Bathmodon.—Proceedings of the Academy of Natural Sciences, Vol. XXVII, p. 73. Philadelphia, May, 1875.

The *Dinocerata*, from the structure of the feet, regarded as a suborder.

1876.

Marsh, Othniel Charles.—Principal Characters of the Dinocerata, Part I.—American Journal of Science and Arts (3), Vol. XI, pp. 163–168, Plates II–VI. New Haven, February, 1876.

Discussion of the order *Dinocerata*, with plates of the skull, brain-cast, lower jaw, and feet of *Dinoceras*.

Abstract of same.—Nature, vol. xiii, p. 374, London, March 9, 1876.

The same.—Journal de Zoologie, vol. v, pp. 136–145, Paris, 1876.

Abstract of same.—Zeitschrift für die gesammten Naturwissenschaften, vol. xiv, pp. 31, 32, Berlin, 1876.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., pp. 780, 781, Stuttgart, 1876.

Abstract of same.—Popular Science Review, pp. 326, 327, London, July, 1876.

Marsh, Othniel Charles.—The Brain of Dinoceras.—American Naturalist, Vol. X, p. 182. Boston, March, 1876.

Owen, Richard.—On the existence or not of Horns in the Dinocerata.—American Journal of Science and Arts (3), Vol. XI, pp. 401–403. New Haven, May, 1876.

Doubts expressed as to the presence of true horns in the *Dinocerata.* (See page 167 of the present volume).

Marsh, Othniel Charles.—On some of the Characters of the genus Coryphodon, Owen.—American Journal of Science and Arts (3), Vol. XI, pp. 425–428. New Haven, May, 1876.

A comparison of the brain-cast in *Coryphodon* and *Dinoceras.*

Abstract of same.—Popular Science Review, p. 327, London, July, 1876.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., p. 781, Stuttgart, 1876.

Abstract of same.—Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles, vol. lvi, pp. 273, 274, Geneva, 1876.

Flower, William Henry.—On the Extinct Animals of North America.—Popular Science Review, Vol. XV, pp. 276–298, Plate CXXXVIII. London, July, 1876.

Contains a brief description of the *Dinocerata*, with figures of skull and hind feet of *Dinoceras.*

Marsh, Othniel Charles.—Recent Discoveries of Extinct Animals.—American Journal of Science and Arts (3), Vol. XII, pp. 59–61. New Haven, July, 1876.

The same, American Naturalist, Vol. X, pp. 436–439. Boston, July, 1876.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., p. 782, Stuttgart, 1876.

1877.

[Cope, Edward Drinker.]—The Lowest Mammalian Brain.—American Naturalist, Vol. XI, pp. 312 313. Boston, May, 1877.

Marsh, Othniel Charles.—Brain of Coryphodon.—American Naturalist, Vol. XI, p. 375. Boston, June, 1877.

Abstract of same.—Nature, vol. xvii, p. 340, London, February 28, 1878

Cope, Edward Drinker.—Brain of Coryphodon.—Proceedings of the American Philosophical Society, Vol. XVI, pp. 616–620, Plates I, II. Philadelphia, 1877.

Contains a comparison of brain-casts in *Coryphodon* and *Dinoceras.*

Marsh, Othniel Charles.—Principal Characters of the Coryphodontidæ.—American Journal of Science and Arts (3), Vol. XIV, pp. 81–85, Plate IV. New Haven, July, 1877.

A comparison of *Coryphodon* and *Dinoceras*, with figures of the feet in both.

The same.—Journal de Zoologie, vol. vi, pp. 380–385, Paris, 1877.

Abstract of same.—American Naturalist, vol. xi, p. 500, Boston, August, 1877.

Abstract of same.—Neues Jahrbuch für Mineralogie, etc., p. 767, Stuttgart, 1877.

Cope, Edward Drinker.—Report upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874.—United States Geographical Surveys West of the 100th Meridian, Wheeler, Vol. IV, Palæontology, Part II, pp. 179–186, 273, 282. Washington, 1877.

Dinocerata here considered a suborder of the Amblypoda.

Marsh, Othniel Charles.—Introduction and Succession of Vertebrate Life in America.—An Address delivered before the American Association for the Advancement of Science, at Nashville, Tenn., August 30, 1877. Proceedings, Vol. XXVI, pp. 211–258, Salem, 1878.

Contains a reference to the characters and affinities of the *Dinocerata*.

The same published in advance, pp. 1–57. 8vo. New Haven, August, 1877.

The same.—Nature, vol. xvi, pp. 448–450, 470–472, and 489–491, London, September 20, 27, and October 4, 1877.

The same.—American Journal of Science (3), vol. xiv, pp. 337, 378, New Haven, November, 1877.

The same with plate.—Popular Science Monthly, vol. xii, pp. 511–527 and 672–697, New York, March and April, 1878.

The same.—Revue Scientifique de la France et de l' Etranger (2), vol. vii, pp. 1039–1046, and 1064–1074, Paris, May 4 and 11, 1878.

1878.

Gaudry, Albert.—Les Enchaînments du Monde Animal dans les temps Géologiques. Mammifères Tertiares, 8vo, pp. 1–293, figure 86. Paris, 1878.

Marsh, Othniel Charles.—Tinoceras.—Johnson's New Universal Cyclopædia, Vol. IV, pp. 868, 869. New York, 1878.

King, Clarence.—United States Geological and Geographical Exploration of the Fortieth Parallel, Vol. I, Systematic Geology, p. 403. 4to. Washington, 1878.

A partial list of the species of *Dinocerata* occurring in the Bridger beds of the Eocene.

Osborn, Henry Fairfield; Scott, William Berryman; Speir, Francis.—Palæontological Report of the Princeton Scientific Expedition of 1877; Contributions from the Museum of Geology and Archæology of Princeton College, No. 1, 8vo, pp. 146, Plate A, and I–X. New York, 1878.

Contains (pp. 62–82, Plates VI, VII) first descriptions of *Uintatherium Leidianum* and U. princeps, with figures.

Ryder, John A.—On the Mechanical Genesis of Tooth Forms.—Proceedings of the Academy of Natural Sciences for 1878, pp. 45–80. Philadelphia, April, 1878.

1879.

Osborn, Henry Fairfield, and Speir, Francis.—The Lower Jaw of Loxolophodon.—American Journal of Science and Arts (3), Vol. XVII, pp. 304–309, Plate I. New Haven, April, 1879.

Description of the lower jaw of a female *Tinoceras*, or allied genus.

Nicholson, Alleyne.—Manual of Palæontology, 8vo, Vol. II, p. 370–373, figs. 656, 657. Edinburgh and London, 1879.

Description of the *Dinocerata*, with figures of the skull and feet of *Dinoceras mirabile*, from the present volume.

1880.

Dana, James Dwight.—Manual of Geology, Third Edition, 8vo, pp. 504, 508, Plate VII, figs. 1–4; Plate XI, fig. 1. New York, 1880.

A reference to the *Dinocerata*, with figures from the present memoir.

1881.

Cope, Edward Drinker.—On the Vertebrata of the Wind River Eocene Beds of Wyoming.—Bulletin of the United States Geological Survey, F. V. Hayden, Vol. VI, pp. 183–202. Washington, February, 1881.

Contains (pp. 194–196) first description of *Uintatherium fissidens.*

Garrod, Alfred Henry.—Dinocerata.—Journal of Anatomy and Physiology, VII, pp. 267–270. London and Cambridge, June, 1873.

The same, Complete Writings, edited by W. A. Forbes, 8vo, pp. 121–123. London, 1881.

Opinion that the *Dinocerata* belong to a family of the Artiodactyla.

Marsh, Othniel Charles.—Restoration of *Dinoceras mirabile.*—American Journal of Science (3), Vol. XXII, pp. 31, 32, Plate II. New Haven, July, 1881.

The same, published in advance, June 14, 1881.

First restoration of *Dinoceras mirabile*, new characters in the skull and sternum, and distinction stated between this genus and *Uintatherium.*

Abstract of same.—Archives des Sciences Physiques et Naturelles, vol. vi, pp. 323, 324, Geneva, September, 1881.

Osborn, Henry Fairfield.—A Memoir upon Loxolophodon and Uintatherium (Two Genera of the Sub-Order Dinocerata).—Contributions from the E. M. Museum of Geology and Archæology of the College of New Jersey, Vol. I, No. 1, 4to, pp. 54, Plates I–IV. Princeton, 1881.

A general discussion of the *Dinocerata*, and first description of *Tinoceras Speirianum*, with a restoration. The statement on page 17 in regard to the discovery of the *Dinocerata* is erroneous, as the author was nearly two years earlier in the field than is there implied. See Introduction, page 2, of the present volume.

1882.

Cope, Edward Drinker.—Contributions to the History of the Vertebrata of the Lower Eocene of Wyoming and New Mexico, made during 1881.—Proceedings of the American Philosophical Society, number 111, for 1882, pp. 139–197. Philadelphia, 1882.

[Cope, Edward Drinker.]—American Naturalist, Vol. XVI, plate XVII, p. 1029. Philadelphia, December, 1882 ; Vol. XVII, Erratum.

A restoration of *Tinoceras cornutum*, without text.

LeConte, Joseph.—Elements of Geology, Second Edition, pp. 525, 526, figs. 845, 845*a*, 8vo. New York, 1882.

A brief description of *Dinoceras* and *Tinoceras*, with figures from the present volume.

Tomes, Charles Sissmore.—Dental Anatomy, Human and Comparative, 8vo, pp. 440. Second Edition, London, 1882. [*Dinocerata*, pp. 340–342, figure 146.]

1883.

Cope, Edward Drinker.—On Uintatherium and Bathmodon.—American Naturalist, Vol. XVII, p. 68. Philadelphia, January, 1883.

Cope, Edward Drinker.—On Uintatherium, Bathmodon and Triisodon.—Proceedings of the Academy of Natural Sciences for 1882, pp. 294–300. Philadelphia, January, 1883.

Cope, Edward Drinker.—The Classification of the Ungulate Mammalia.—Proceedings of the American Philosophical Society for 1882. Vol. XX, pp. 438–447. Philadelphia, 1883.

Flower, William Henry.—Mammalia.—Encyclopædia Britannica, 9th Edition, Vol. XV, p. 426, fig. 105 (from present volume). Edinburgh, 1883.

Wortman, Jacob L.—The Carpal bones of the Dinocerata.—Science, Vol. I, p. 151. Cambridge, March 9, 1883.

1884.

Marsh, Othniel Charles.—The Gigantic Mammals of the Order Dinocerata. Fifth Annual Report of the United States Geological Survey, 8vo, pp. 245–302, figs. 36–137. Washington, 1884.

An extended abstract of the present volume, with 102 illustrations.

Cope, Edward Drinker.—The Amblypoda.—American Naturalist, Vol. XVIII, pp. 1110–1121, figs. 7, 8, 10. Philadelphia, November, 1884.

Contains figures of the lower jaw of *Uintatherium fissidens.*

POSTSCRIPT.

The Plates of the present volume, with their accompanying pages of explanations, were nearly all printed in 1881 and 1882, and the last of the series, in February, 1883. Most of the other illustrations, also, were completed by the latter date. In consequence of an unexpected delay in printing the text, some of the figures prepared for the Monograph first appeared elsewhere.

An extended abstract of this volume, with 102 illustrations, was prepared by the author, in July, 1884, for the Fifth Annual Report of the Director of the United States Geological Survey, and references to the pages of this Report will be found in the preceding Synopsis.

With the permission of the Director of the United States Geological Survey, an author's edition of 500 copies of this work was printed in February, 1885.

INDEX.

○

PLATE I.

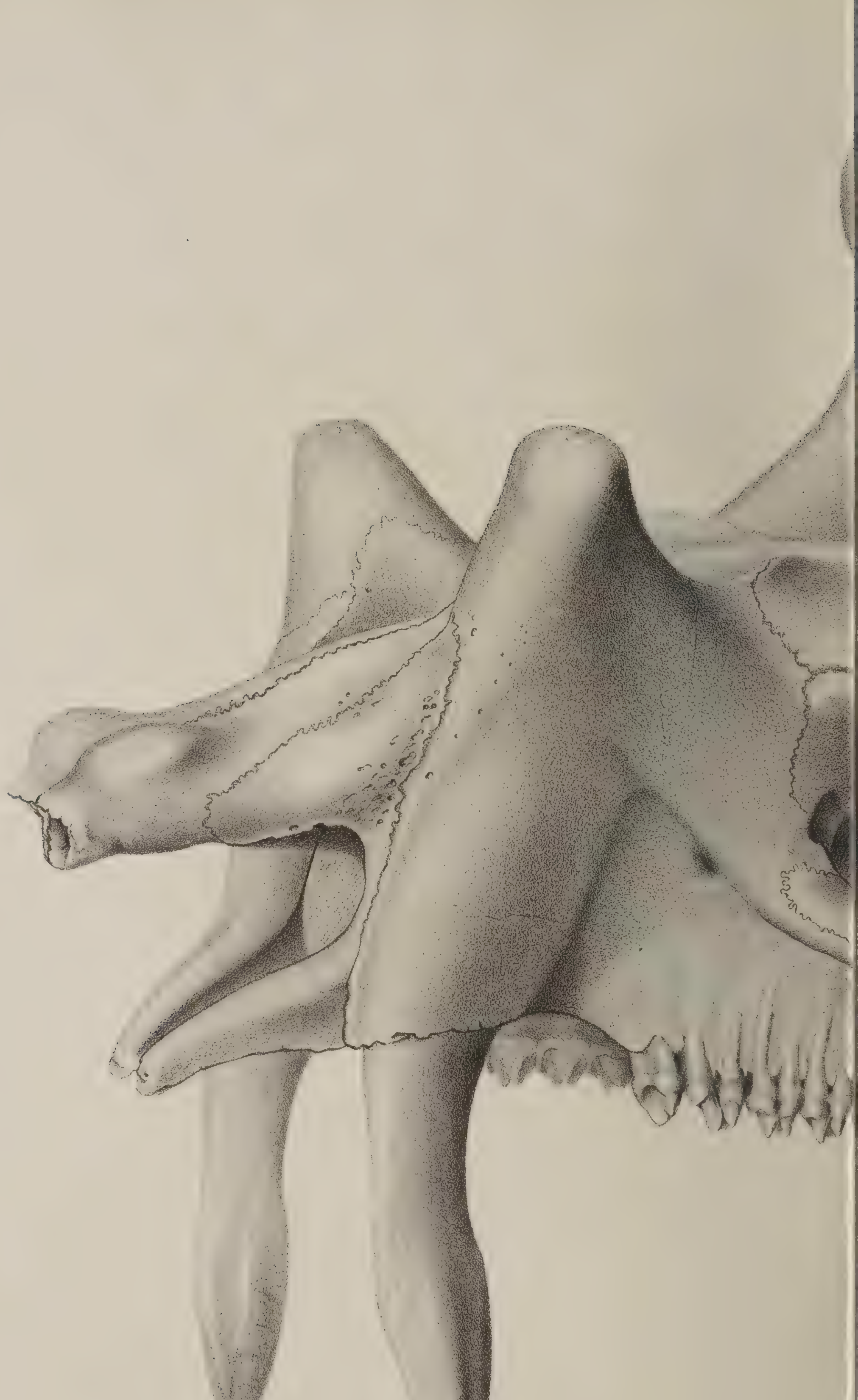
PLATE I.

DINOCERATA.

Skull of DINOCERAS MIRABILE, Marsh.

Two-fifths Natural Size.

This skull, from which the figures on the next six plates are also drawn, belonged to an animal fully adult, as shown by the teeth, but not so old as to have the cranial sutures obliterated. The right canine is restored from the left, which is perfect.



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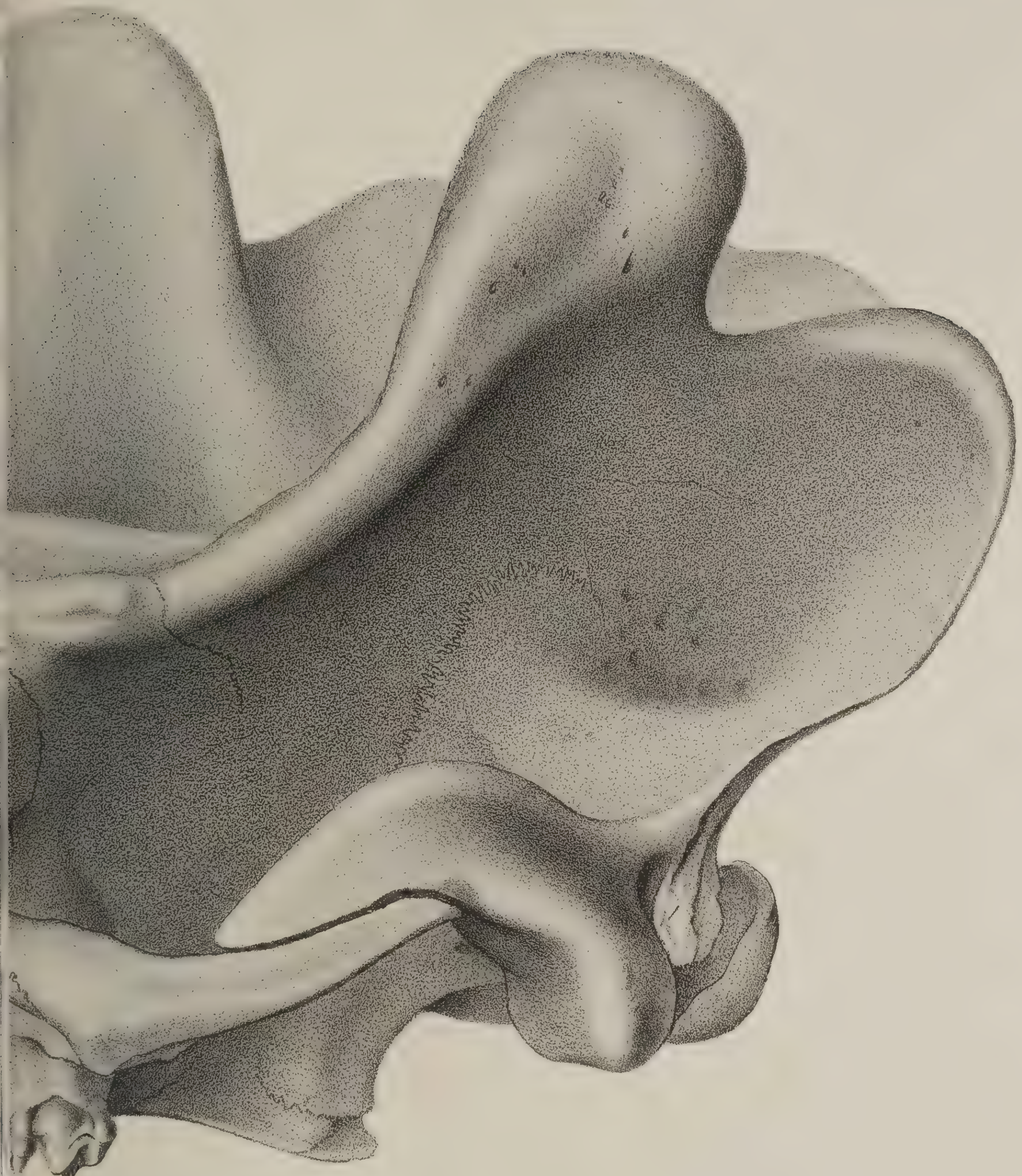
DINOCERAS M



E. Crisand, lith New Haven.

RABILE, Marsh. 2/5

PLATE II.

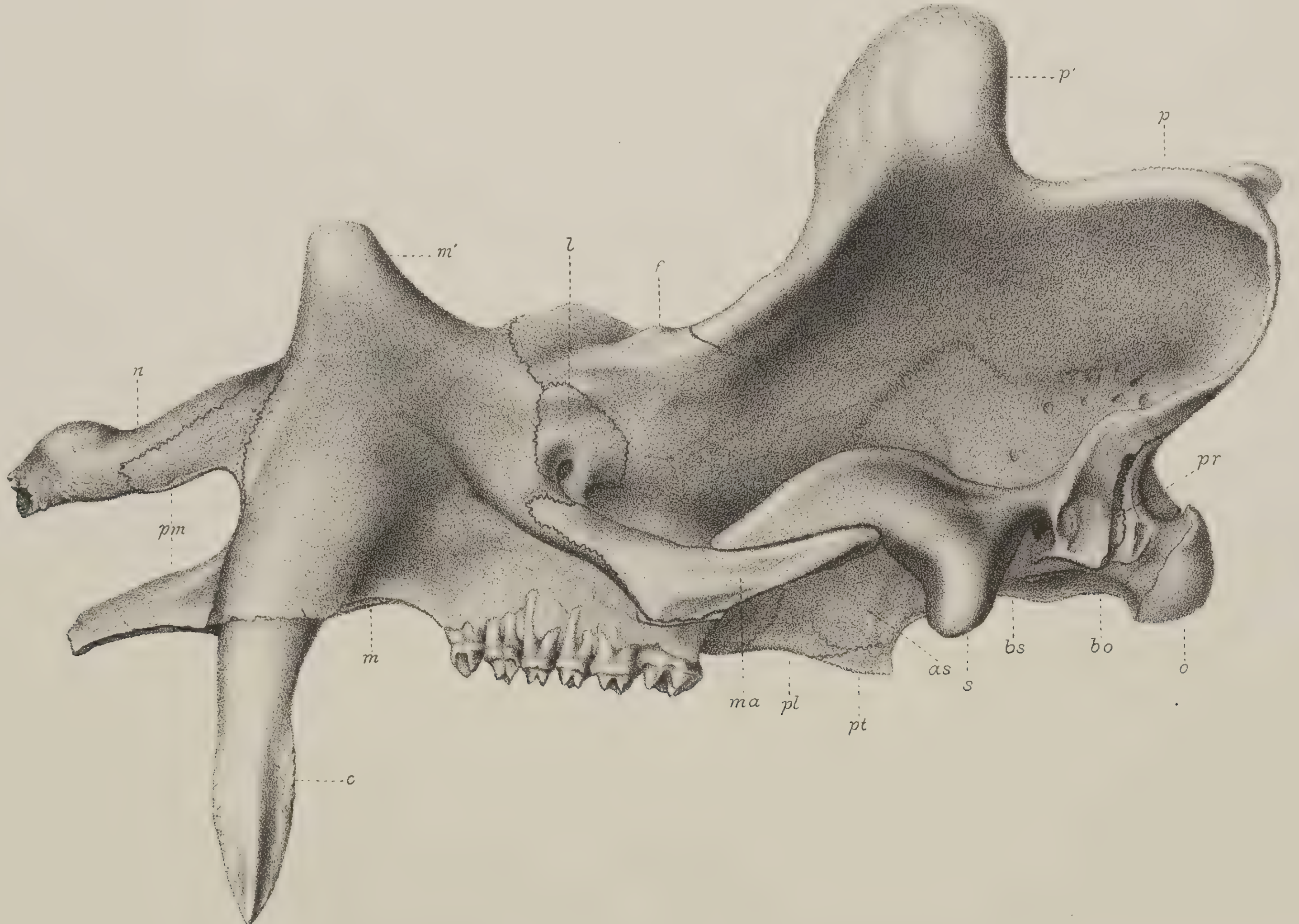
PLATE II.

DINOCERATA.

Skull of DINOCERAS MIRABILE, **Marsh.**

One-fourth Natural Size.

n —Nasal bone.
pm—Premaxillary.
c —Canine tooth.
m —Maxillary bone.
m′ —Maxillary protuberance.
l —Lachrymal bone.
f —Frontal.
ma—Malar.
pl —Palatine.
pt —Pterygoid.
as —Alisphenoid.
s —Post-glenoid process of squamosal.
bs —Basisphenoid.
bo —Basioccipital.
o —Occipital condyle.
p —Posterior crest.
p′ —Posterior protuberance.



DINOCERAS MIRABILE, Marsh. 1/4.

PLATE III.

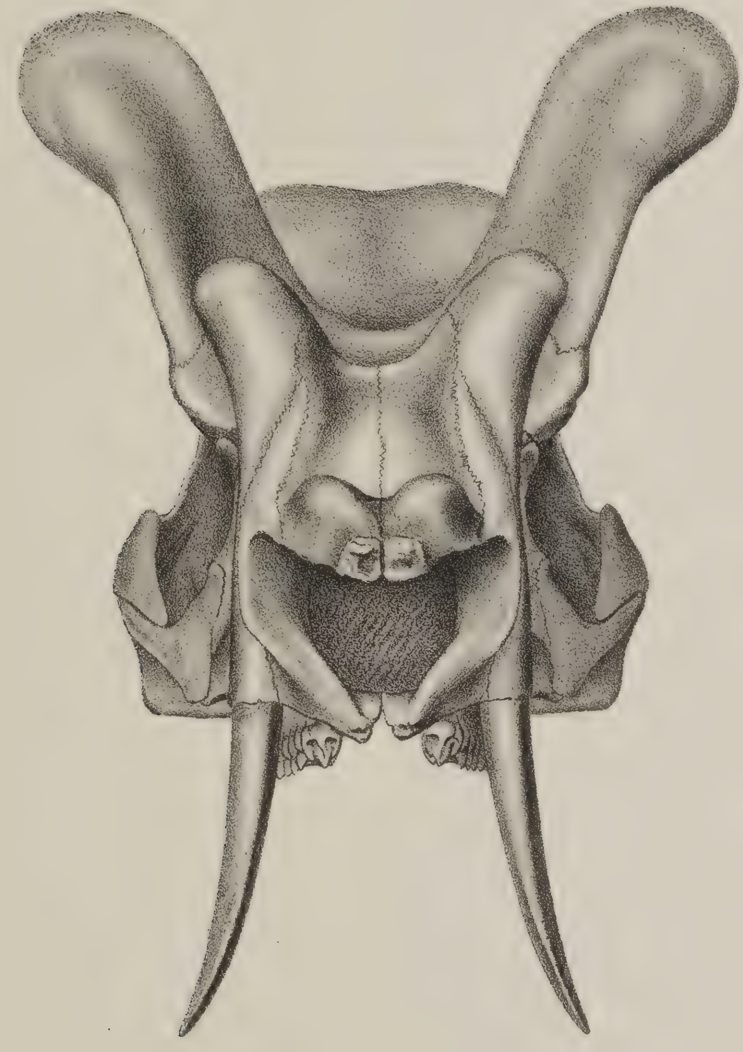
PLATE III.

DINOCERATA.

Skull of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

NOTE.—The surface covered by oblique bars in this and the following plates indicates portions concealed by the adhering matrix or otherwise obscured.



F Berger, del

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ¼.

PLATE IV.

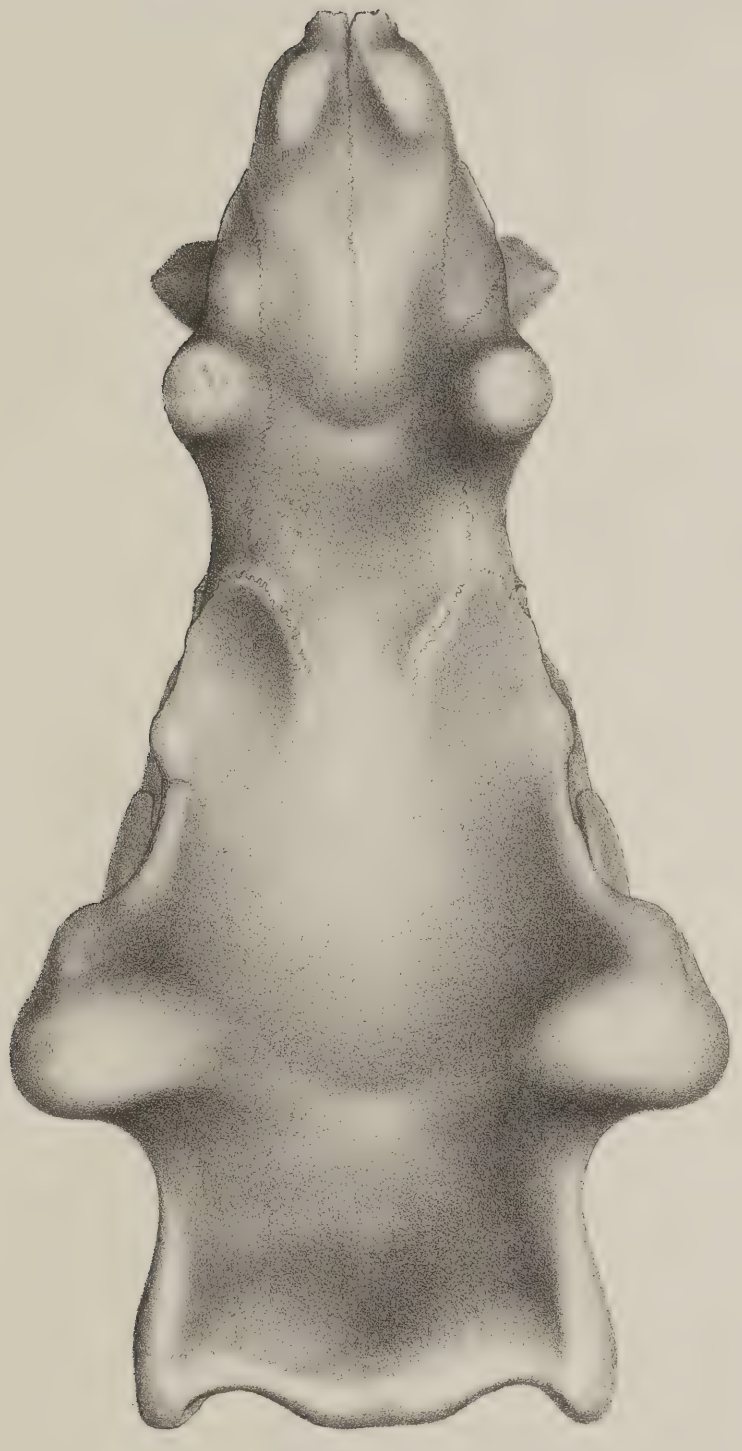
PLATE IV.

DINOCERATA.

Skull of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

F. Berger, del.



DINOCERAS MIRABILE, Marsh. 1/4.

E. Crisand, lith. New Haven.

PLATE V.

PLATE V.

DINOCERATA.

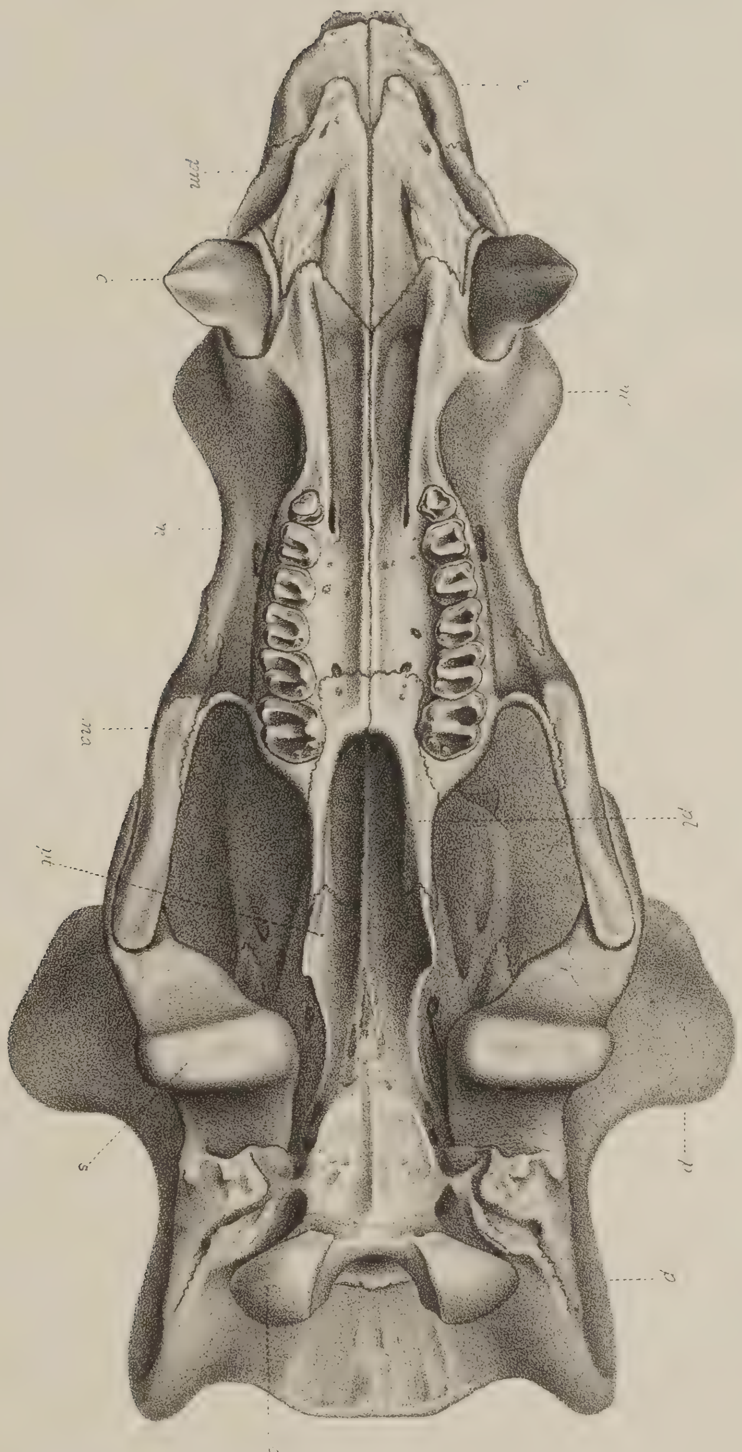
Skull of Dinoceras mirabile, Marsh.

One-fourth Natural Size.

Page.

n —Nasal bone.
pm—Premaxillary.
c —Canine tooth.
m —Maxillary bone.
m′ —Maxillary protuberance.
ma—Malar bone.
pl —Palatine.
pt —Pterygoid.
s —Post-glenoid process of squamosal.
o —Occipital condyle.
p —Posterior crest.
p′ —Posterior protuberance.

F. Berger, del.



DINOCERAS MIRABILE, Marsh. ¼.

E. Crisand lith New Haven

PLATE VI.

PLATE VI.

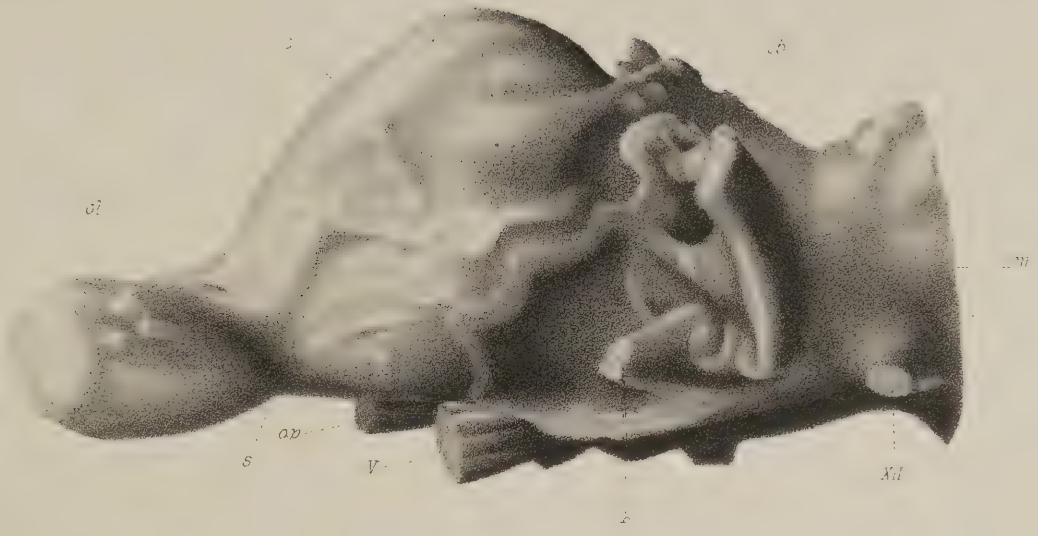
DINOCERATA.

Brain-cast of DINOCERAS MIRABILE, Marsh.

Three-fourths Natural Size.

ol or *I*—Olfactory lobes.
c —Cerebral hemispheres.
s —Sylvian fissure.
op or *II*—Optic nerves.
V —Trigeminal, or fifth, nerve
P —Pituitary body.
f —Flocculus.
f' —Sixth nerve.
cb —Cerebellum.
cf or *XII*—Condylar foramen for twelfth nerve.
m —Medulla.

1



2

3

E. Crisand. ...e

E. Crisand. lith. New Haven

DINOCERAS MIRABILE, Marsh. 3/4

PLATE VII.

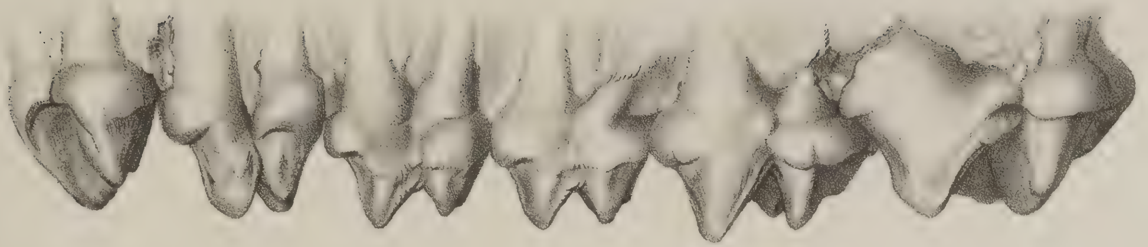
PLATE VII.

DINOCERATA.

Molars of DINOCERAS MIRABILE, Marsh.

Natural Size.

1



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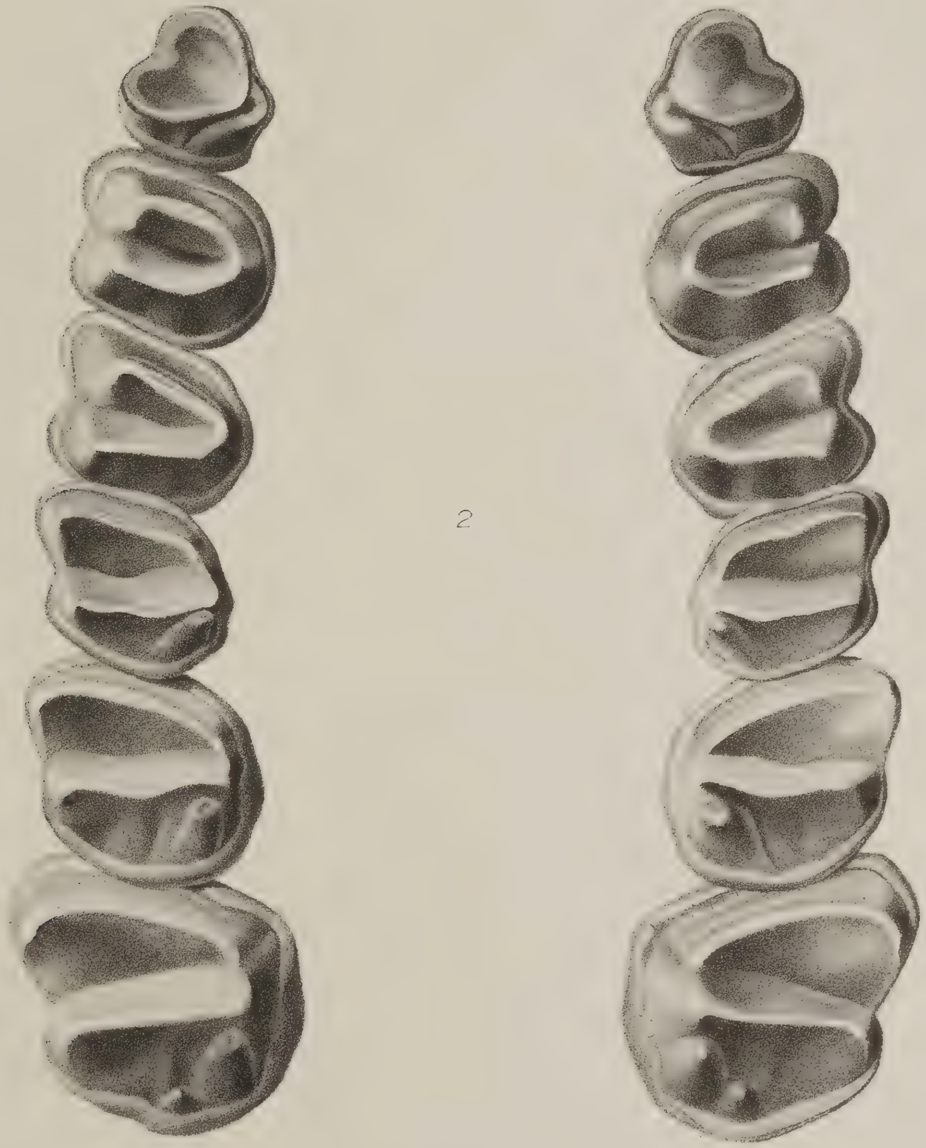


F. Berger, del.

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. 1/1.

PLATE VIII.

PLATE VIII.

DINOCERATA.

Lower jaw and teeth of DINOCERAS MIRABILE, Marsh. Page.

FIG. 1.—Right lower jaw; lateral view, inner side, one-third natural size, 49

i —First incisor tooth.
c —Canine tooth.
d —Diastema.
s —Section through symphysis.
cp —Process for protection of canine tusk.
a —Angle of jaw.
f —Dental foramen.
cd —Condyle.
cr —Coronoid process.

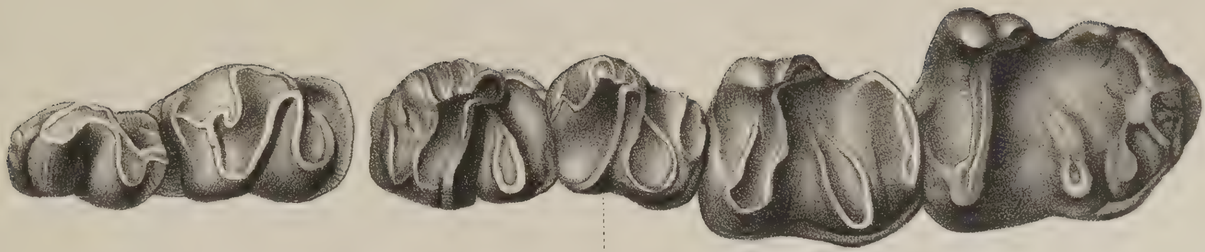
FIG. 2.—Left lower molars; superior view, natural size, 50

FIG. 3.—The same; lateral view, natural size, 50

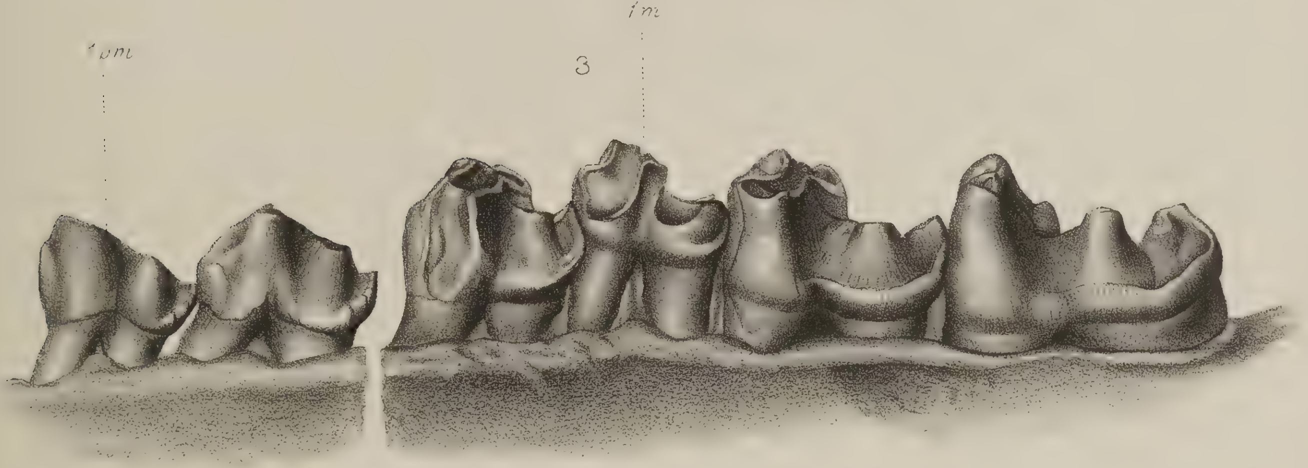
1 *pm*—First premolar.
1 *m* —First molar.

The first and second premolars in figures 2 and 3 are restored from a second specimen.

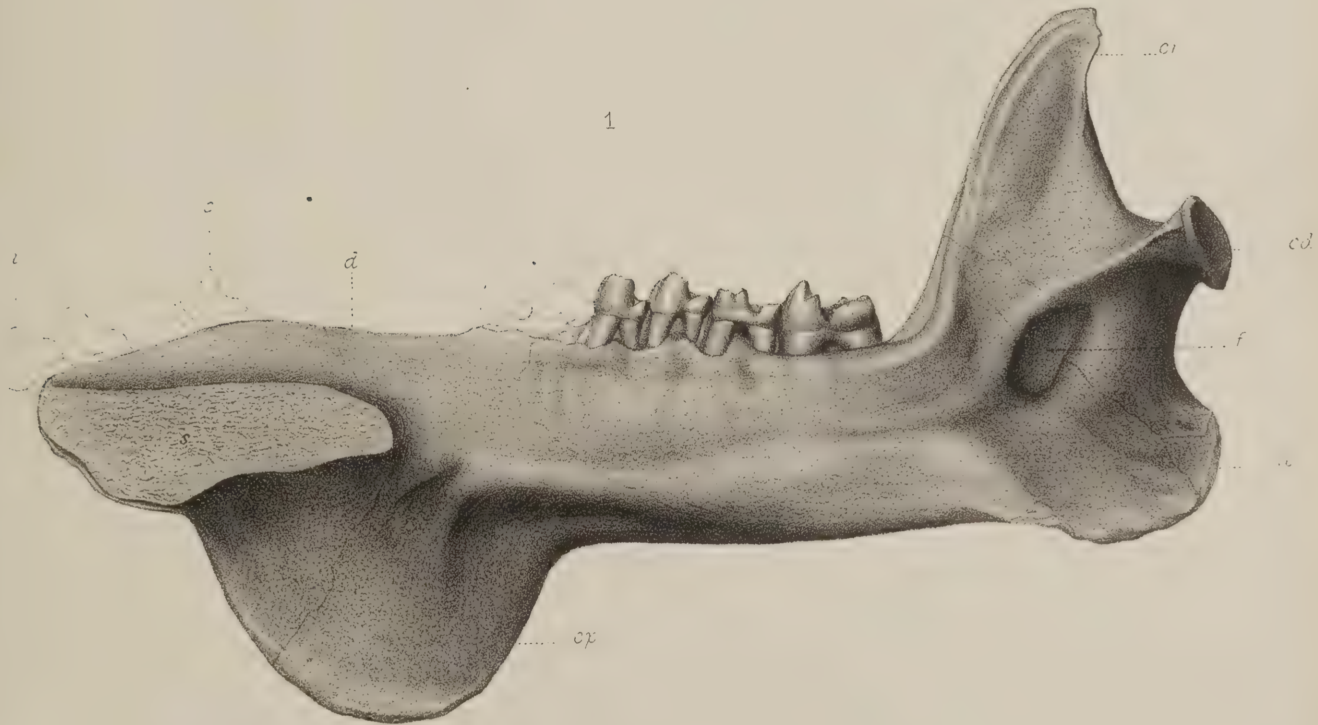
2



3



1



F Berger, del

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh

PLATE IX.

PLATE IX.

DINOCERATA.

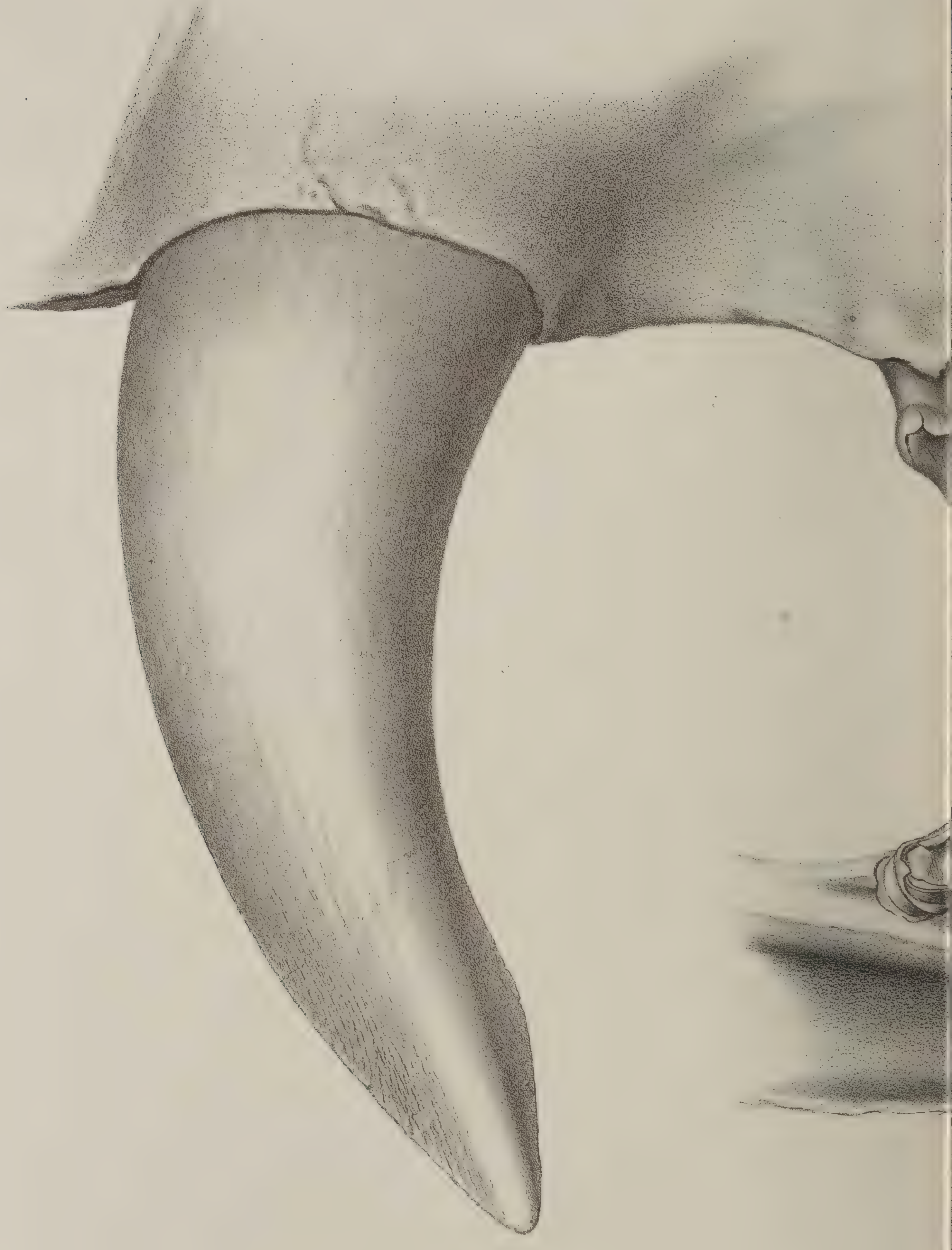
Teeth of DINOCERAS LUCARE, **Marsh.**

Natural Size. Page.

FIG. 1.—Upper molars and canine; type specimen, (No. 1038,) lateral view, seen from the left, 45

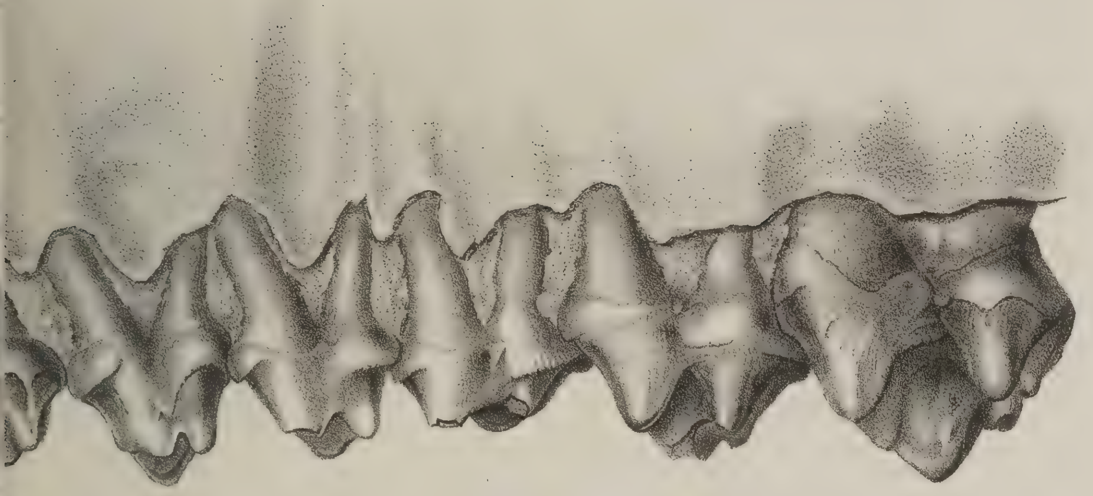
FIG. 2.—Upper molars; showing grinding surface, -- 49

c —Canine tooth.
d —Diastema.
1*p* —First premolar.
1*m*—First molar.
f —Posterior palatine foramen.
f′ —Palato-maxillary foramen.



F Berger, del.

DINOCERAS L



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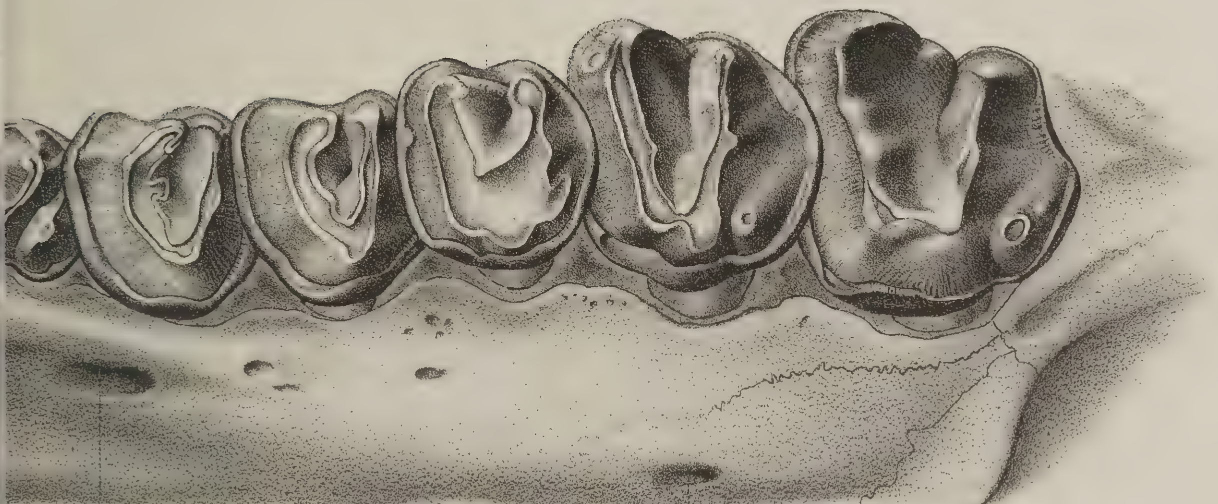


E Crisand lith New Haven

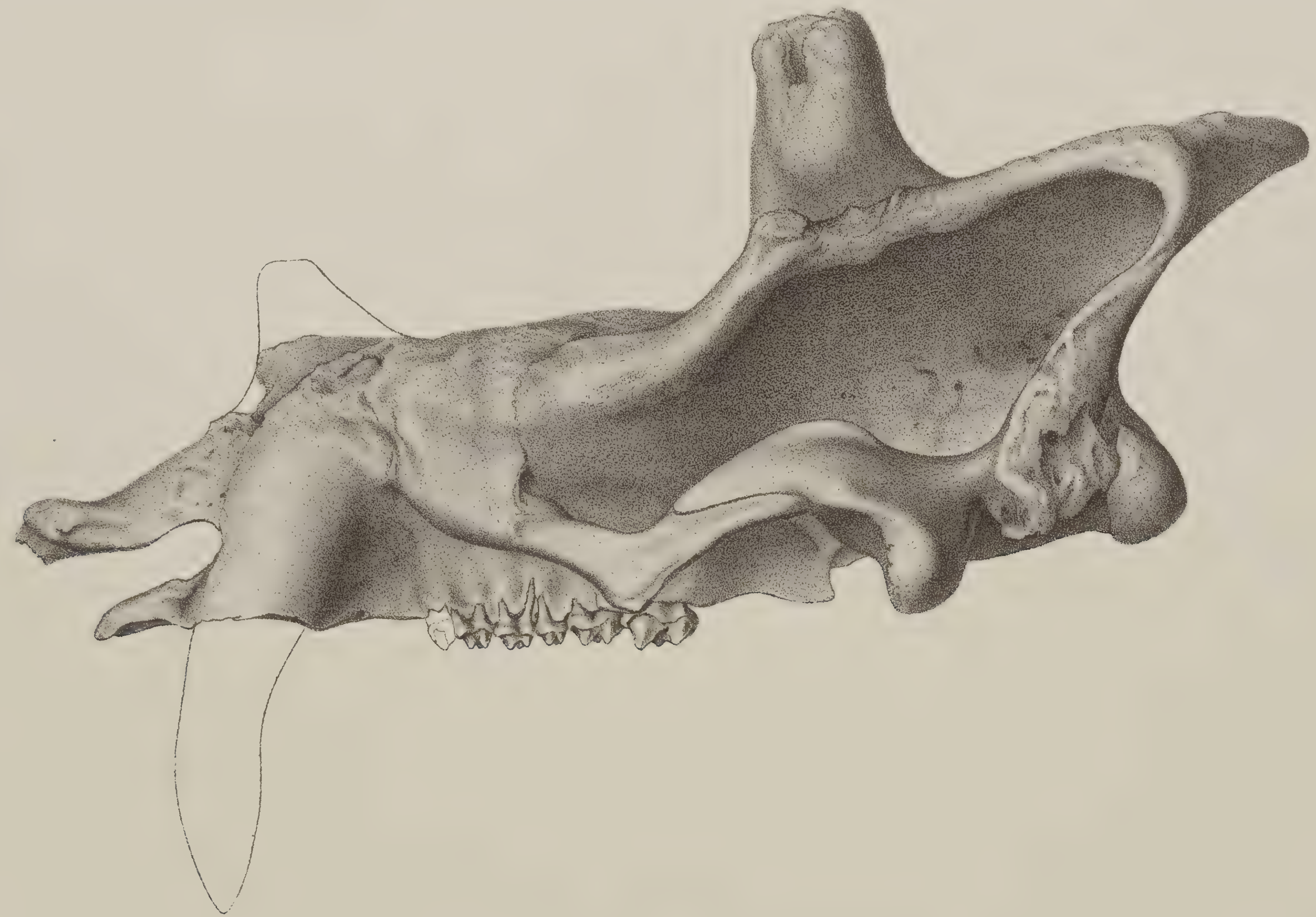
CARE, March 1/1.

PLATE X.

PLATE X.

DINOCERATA.

Skull of DINOCERAS LATICEPS, Marsh



E. Crisand Lith. New Haven.

DINOCERAS LATICEPS. Marsh 1/4

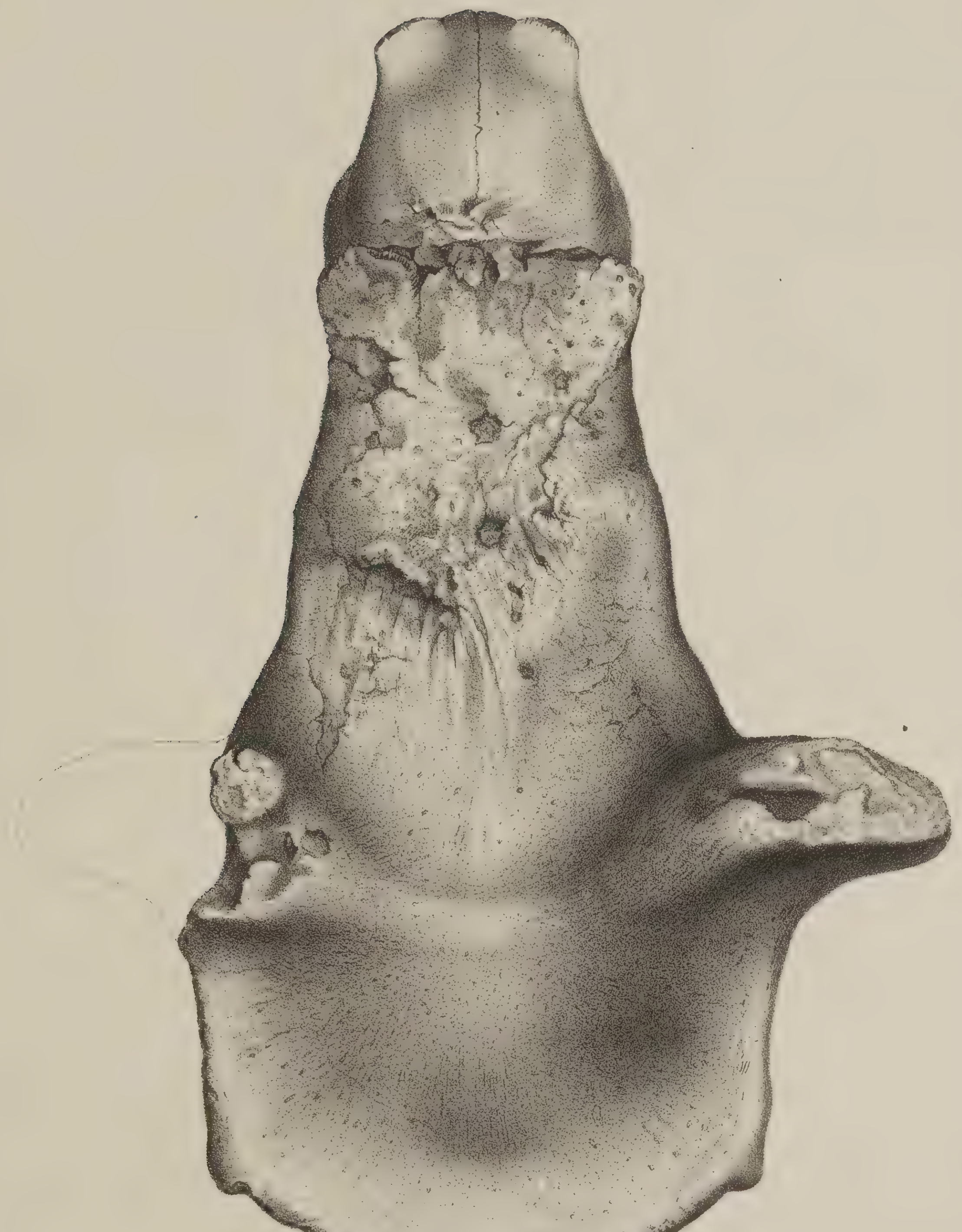
PLATE XI.

DINOCERATA.

Skull of DINOCERAS LATICEPS, **Marsh.**

One-fourth Natural Size.

PLATE XI.



F. Berger, del.

DINOCERAS LATICEPS, Marsh. 1/4.

E. Crisand, lith New Haven.

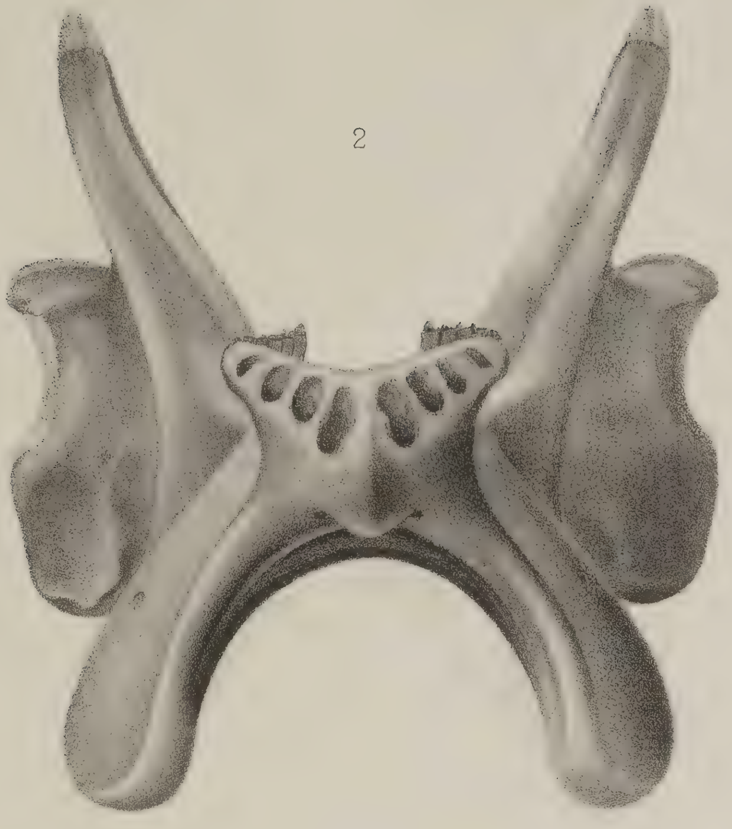
PLATE XII.

PLATE XII.

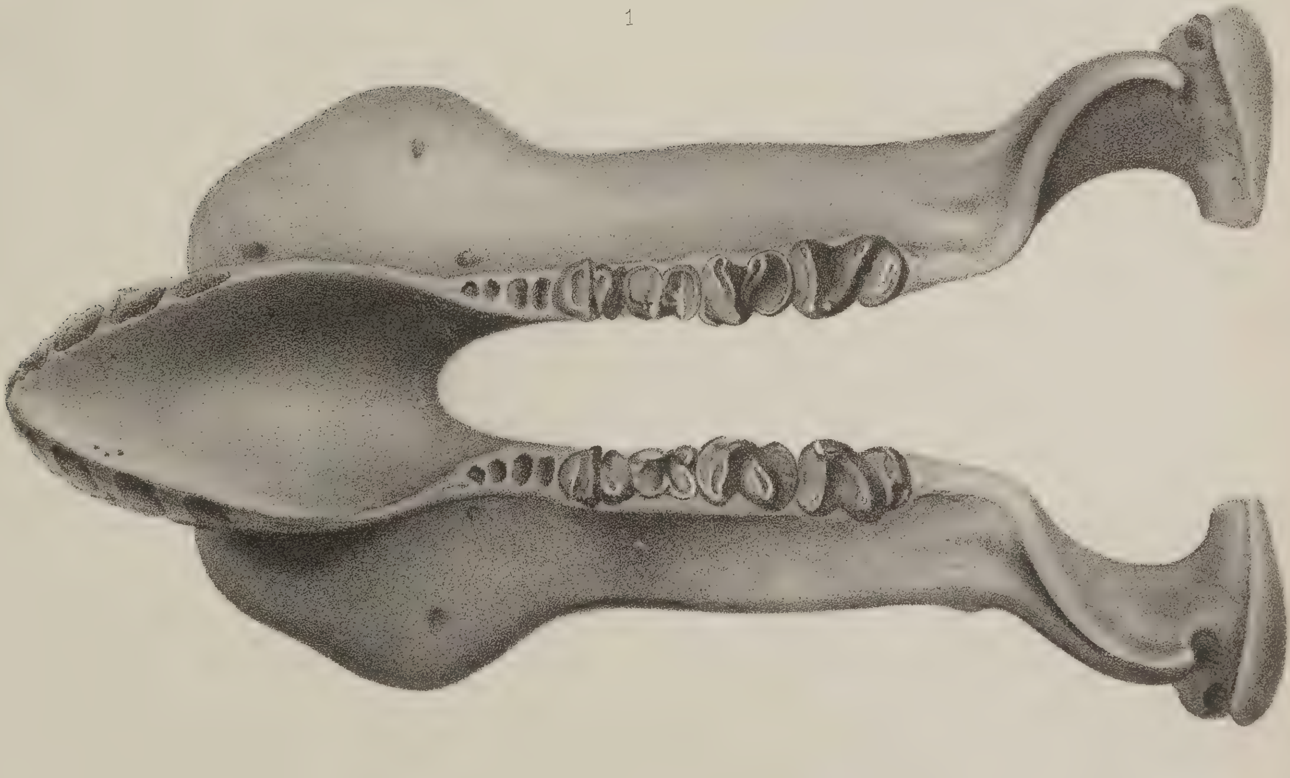
DINOCERATA.

Lower jaw of DINOCERAS LATICEPS, Marsh.

2



1



E. Orisand, del.

E. Orisand, lith. New Haven.

DINOCERAS LATICEPS, Marsh. 1/3.

PLATE XIII.

PLATE XIII.

DINOCERATA.

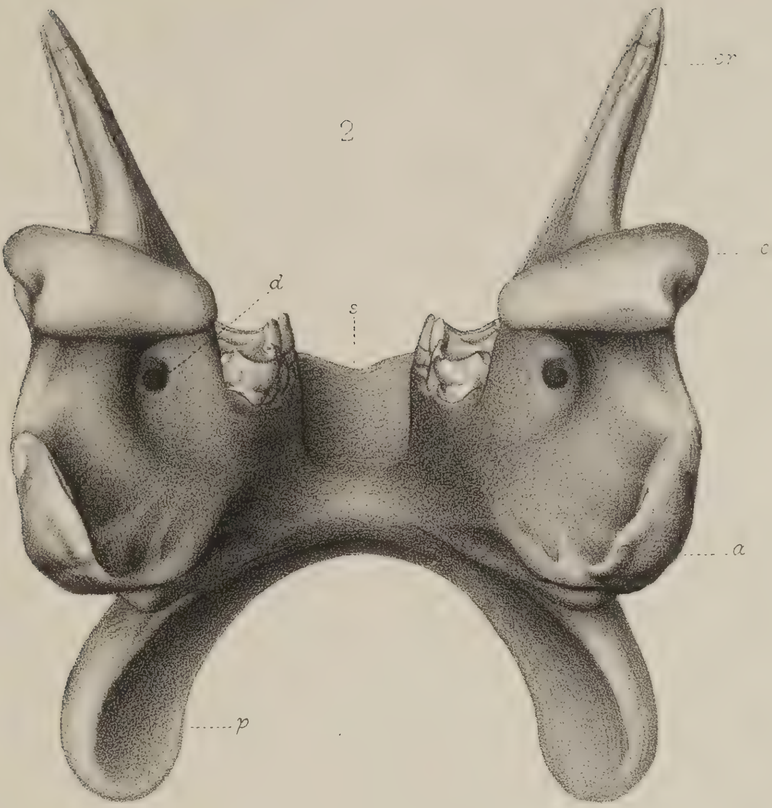
Lower jaw of DINOCERAS LATICEPS, Marsh.

One-third Natural Size.

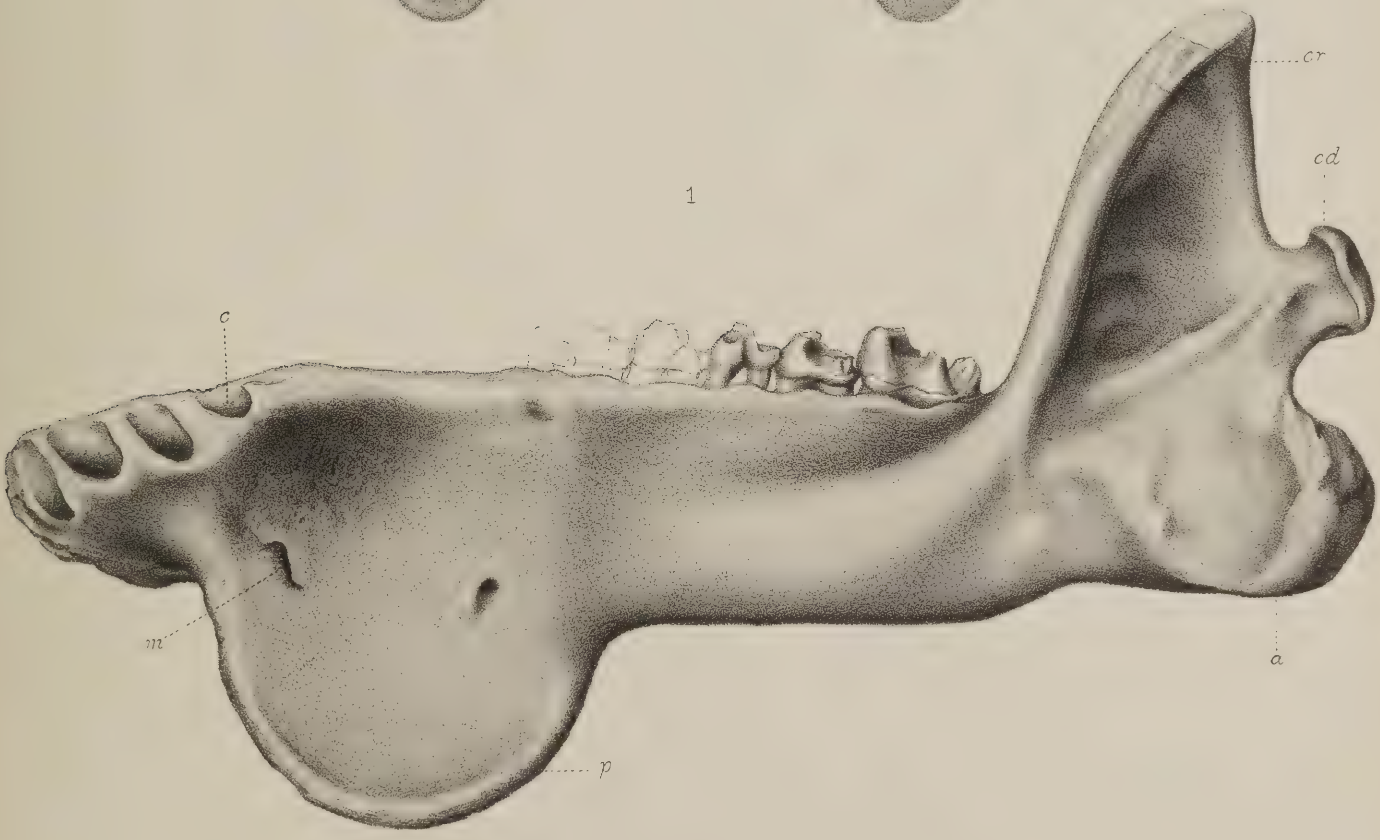
	Page.
FIG. 1.—Lower jaw; (No. 1039,) seen from the left,	35
FIG. 2.—Lower jaw; posterior view,	35

c —Socket for canine tooth.
m —Mental foramen.
p —Process for protection of canine tusk.
a —Angle of jaw.
cd—Condyle.
cr—Coronoid process.
d —Dental foramen.
s —Symphysis.

2



1



F Berger, del

E. Crisand, lith New Haven.

DINOCERAS LATICEPS, Marsh. 1/3.

PLATE XIV.

DINOCERATA.

Skull of DINOCERAS LATICEPS, Marsh, (female.)

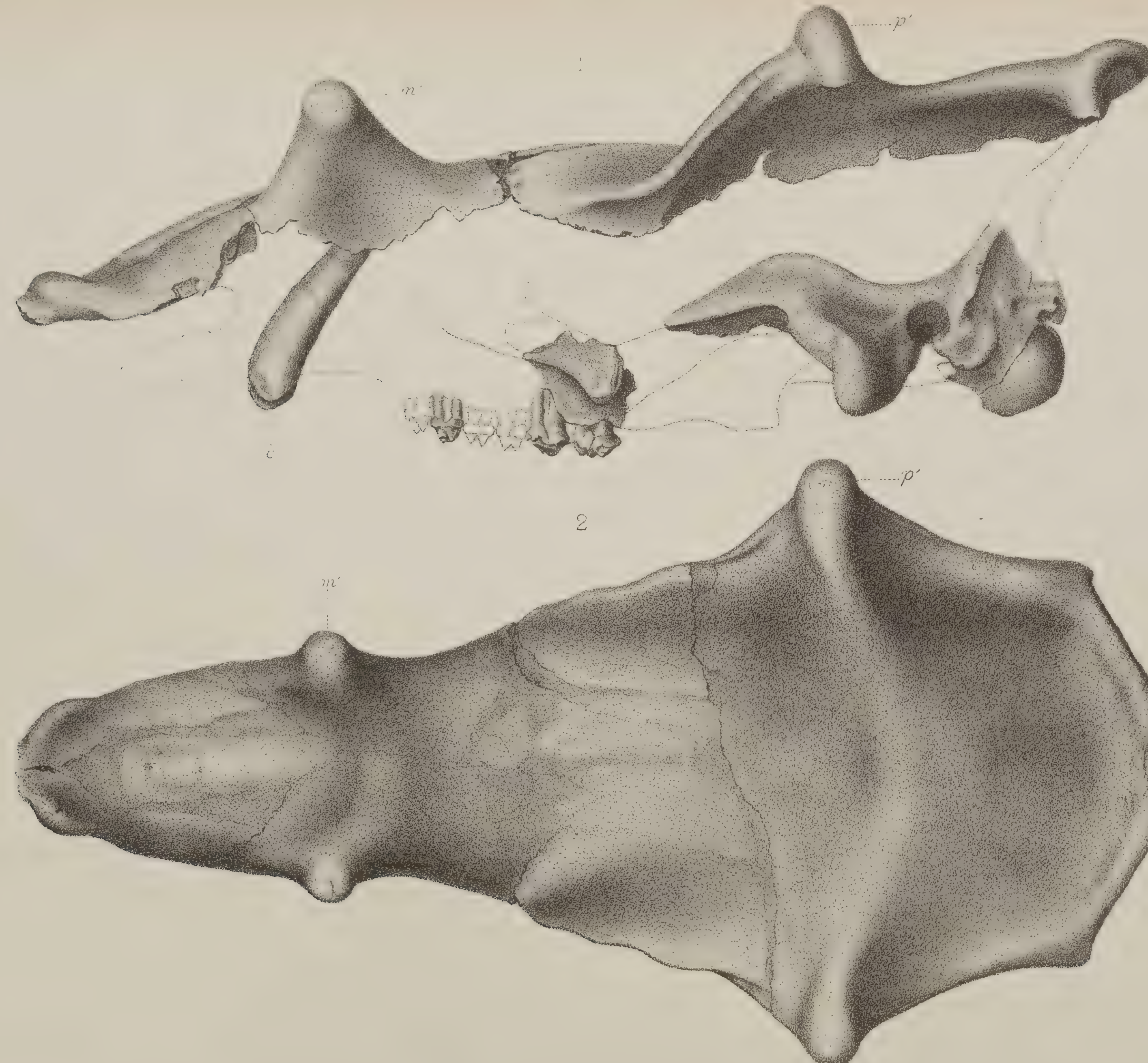
One-fourth Natural Size.

Page.

c —Canine tusk.

m′—Maxillary protuberance.

p′ —Posterior protuberance.



F. Berger. del

E. Crisand, lith. New Haven.

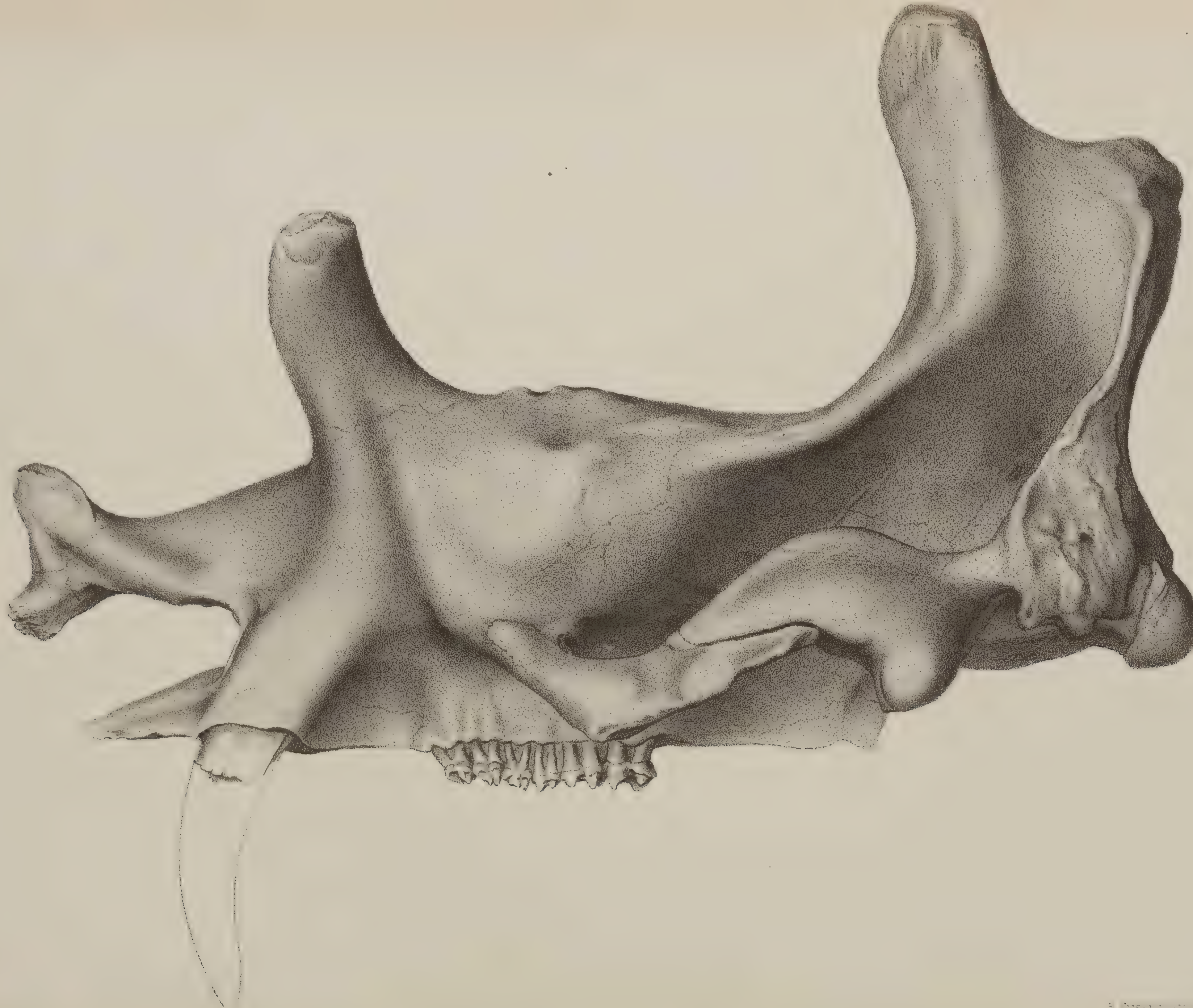
DINOCERAS LATICEPS, Marsh. 1/4.

PLATE XV.

PLATE XV.

DINOCERATA.

Skull of Tinoceras ingens, **Marsh.**



F. Berger, del.

E. Crisand, lith. New Haven.

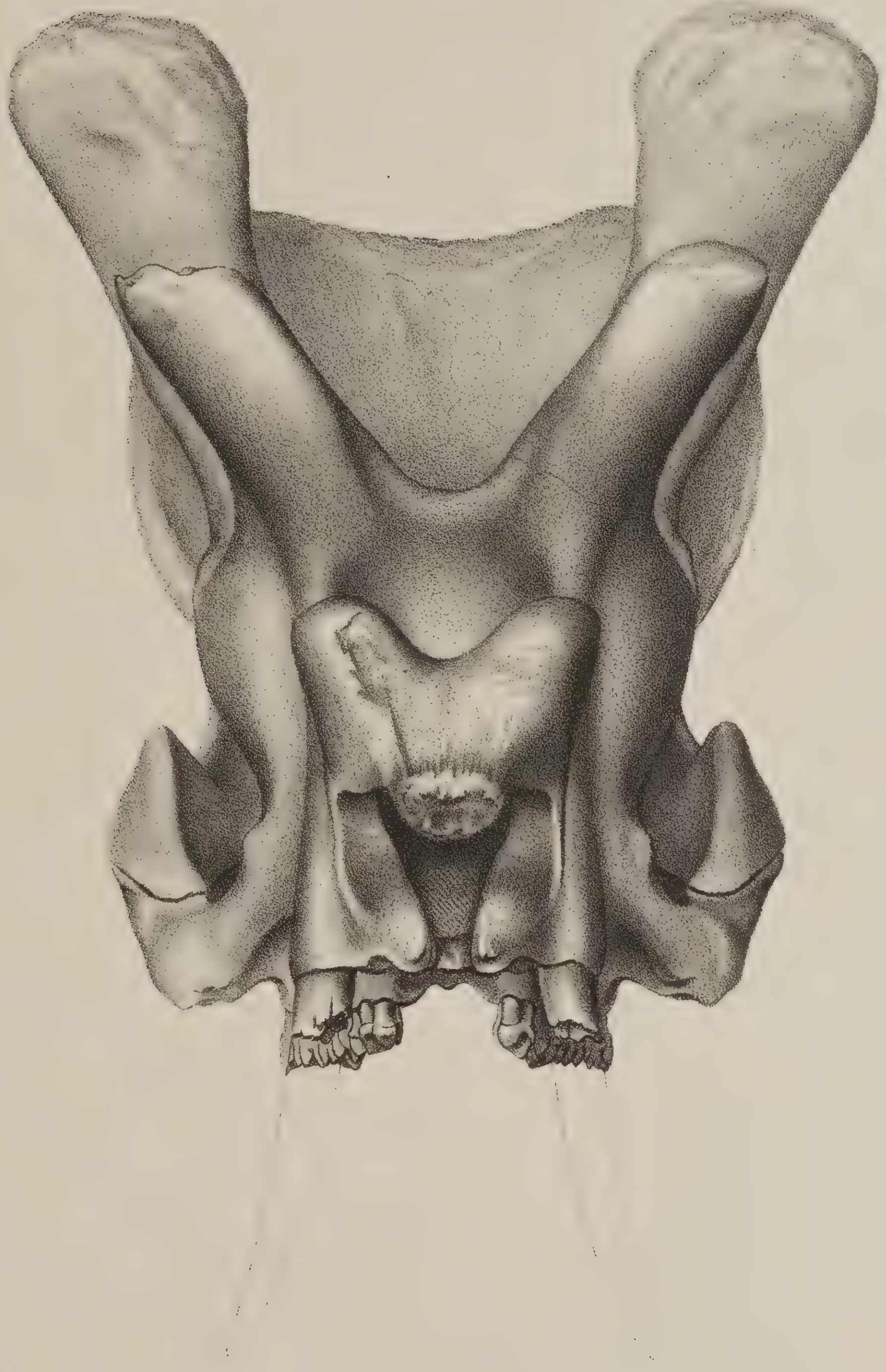
TINOCERAS INGENS, Marsh. 1/4.

PLATE XVI.

PLATE XVI.

DINOCERATA.

Skull of TINOCERAS INGENS, Marsh.



F. Berger, del.

TINOCERAS INGENS, Marsh. 1/4

PLATE XVII.

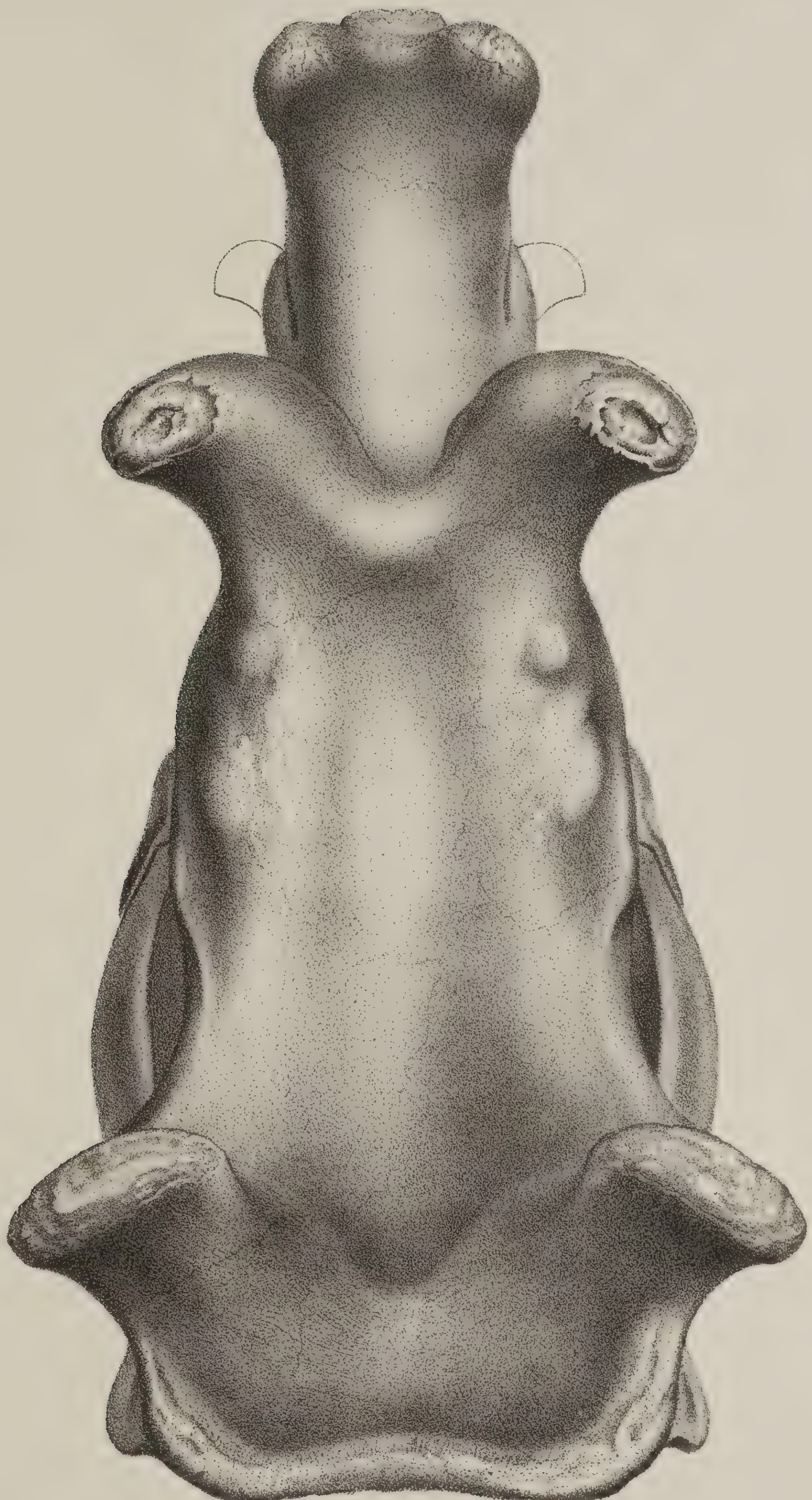
PLATE XVII.

DINOCERATA.

Skull of TINOCERAS INGENS, Marsh.

One-fourth Natural Size.

PLATE XVII.



TINOCERAS INGENS, Marsh. ¼.

E. Crisand. lith New Haven.

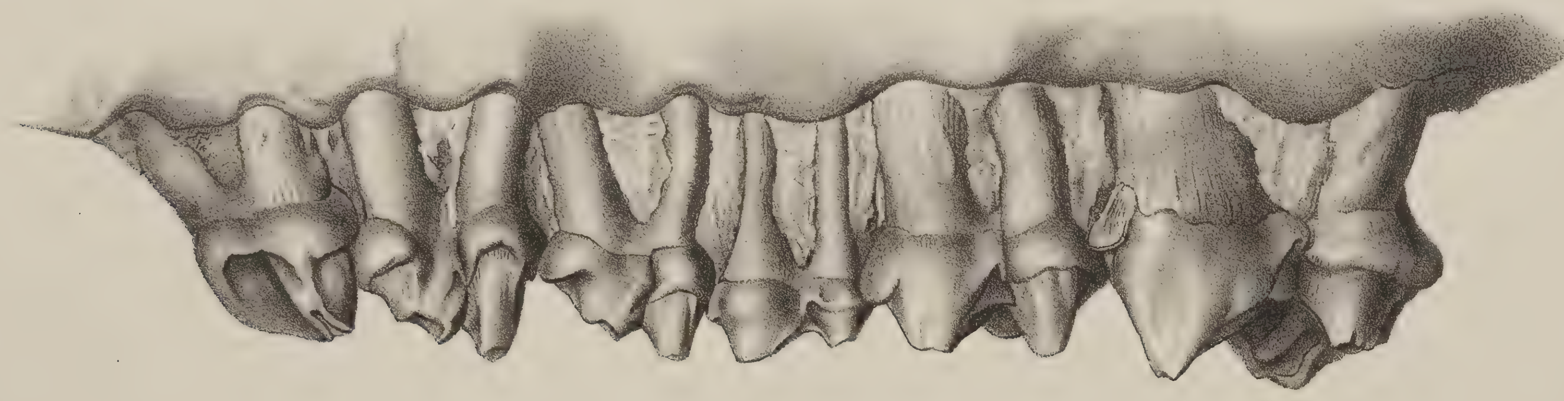
PLATE XVIII.

PLATE XVIII.

DINOCERATA.

Teeth of TINOCERAS INGENS, Marsh.

1



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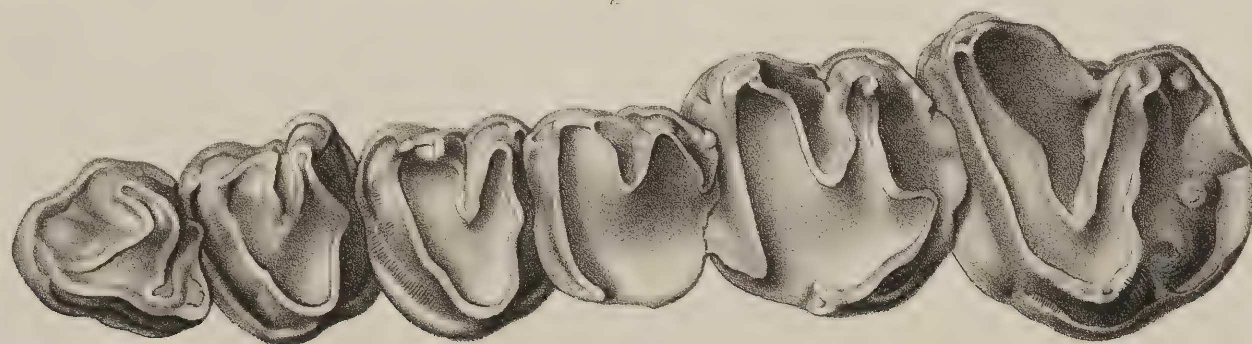


TINOCERAS INGENS, Marsh. ¼.

PLATE XIX.

PLATE XIX.

DINOCERATA.

Lower jaw and teeth of TINOCERAS PUGNAX, Marsh. Page.

FIG. 1.—Lower jaw; lateral view, seen from the left, one-third natural size, ... 35

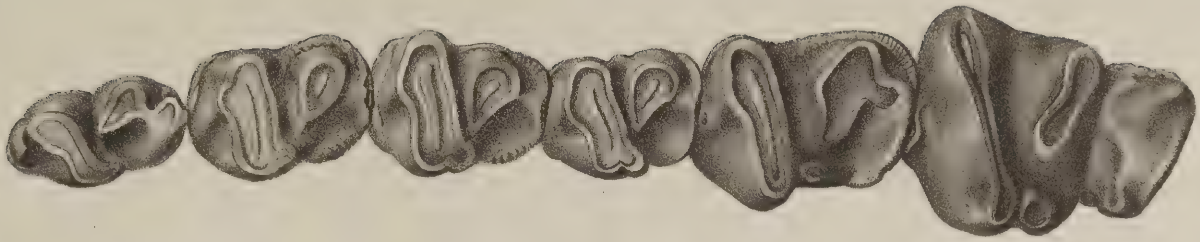
i —Incisor tooth.
c —Canine tooth.
d —Diastema.
f —Mental foramen.
cp —Process for protection of canine tusk.
a —Angle of the jaw.
cd —Condyle.
cr —Coronoid process.

FIG. 2.—Lower molars; superior view, natural size, ... 41

FIG. 3.—The same; lateral view, natural size; 41

1*pm*—First premolar
1*m* —First molar.

2



3

1

F Berger, del

E Crisand, lith New Haven.

TINOCERAS PUGNAX, Marsh.

PLATE XX.

PLATE XX.

DINOCERATA.

Atlas of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

F Berger, del

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. 1/4

PLATE XXI.

PLATE XXI.

DINOCERATA.

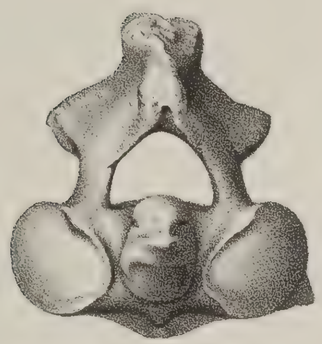
Axis of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

PLATE XXI

1

3



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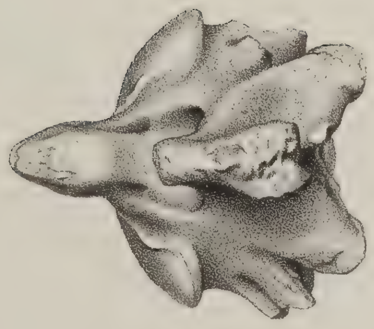

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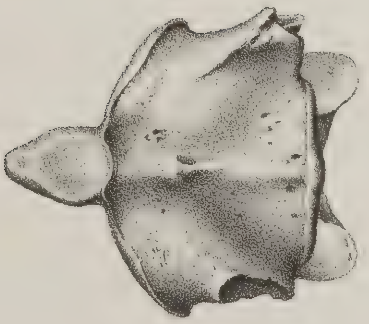


F. Berger, del.

E. Crisand, lith. New Haven

DINOCERAS MIRABILE, Marsh. ¼.

PLATE XXII.

PLATE XXII.

DINOCERATA.

Cervical Vertebræ of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

F Berger, del

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XXIII.

PLATE XXIII.

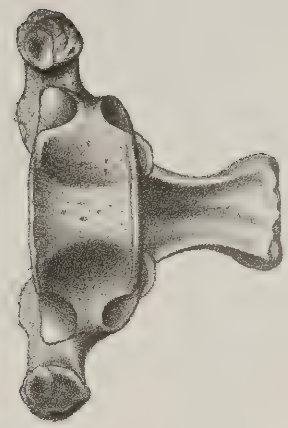
DINOCERATA.

Dorsal Vertebra of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

2

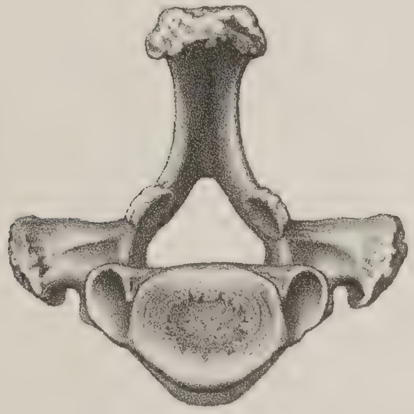
4



1

3

5



E Crisand

DINOCERAS MIRABILE, Marsh. ¼.

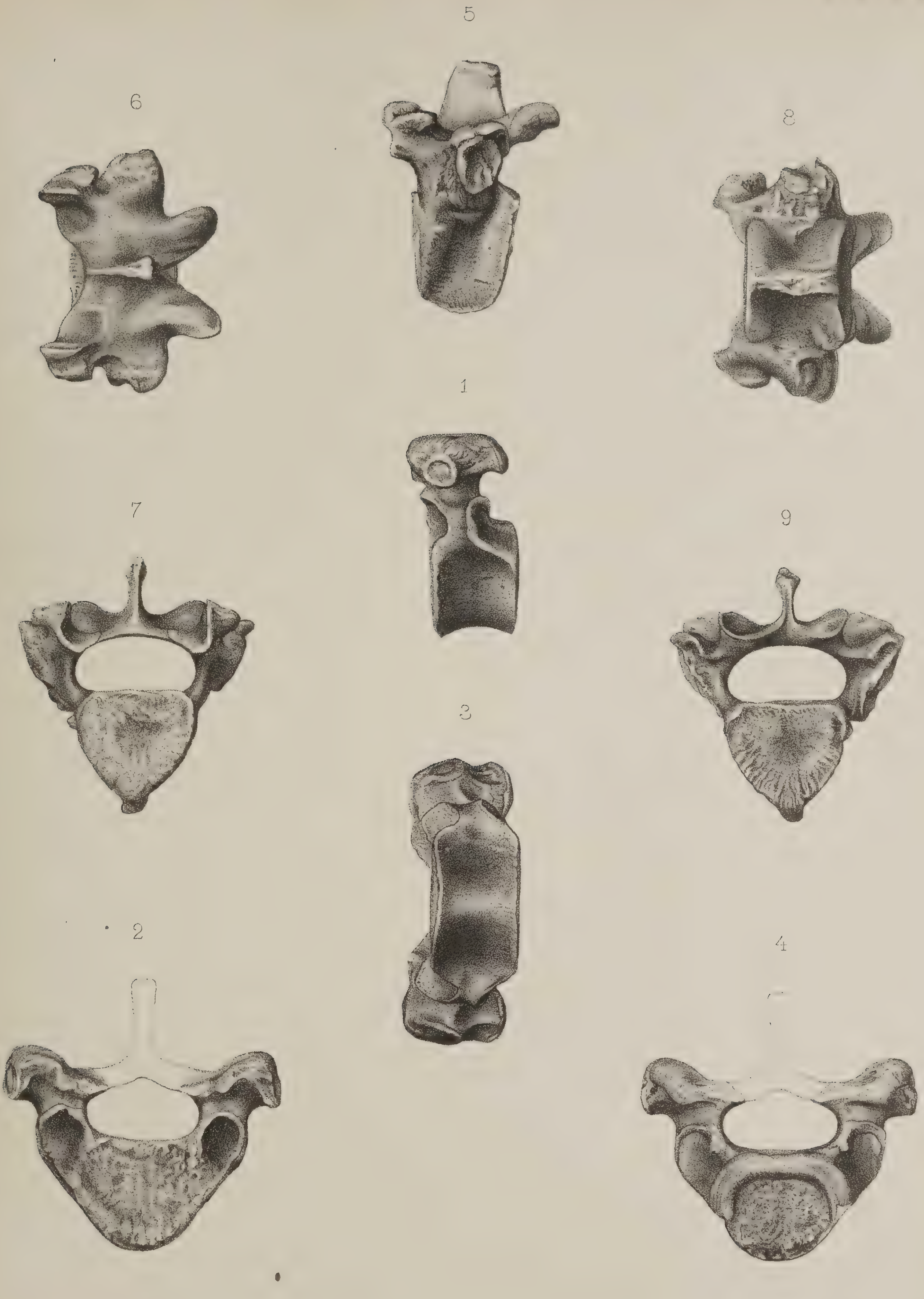
PLATE XXIV.

PLATE XXIV.

DINOCERATA.

Dorsal Vertebræ of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.



F Berger, del

E Crisand. lith New Haven

DINOCERAS MIRABILE, Marsh. ¼.

PLATE XXV.

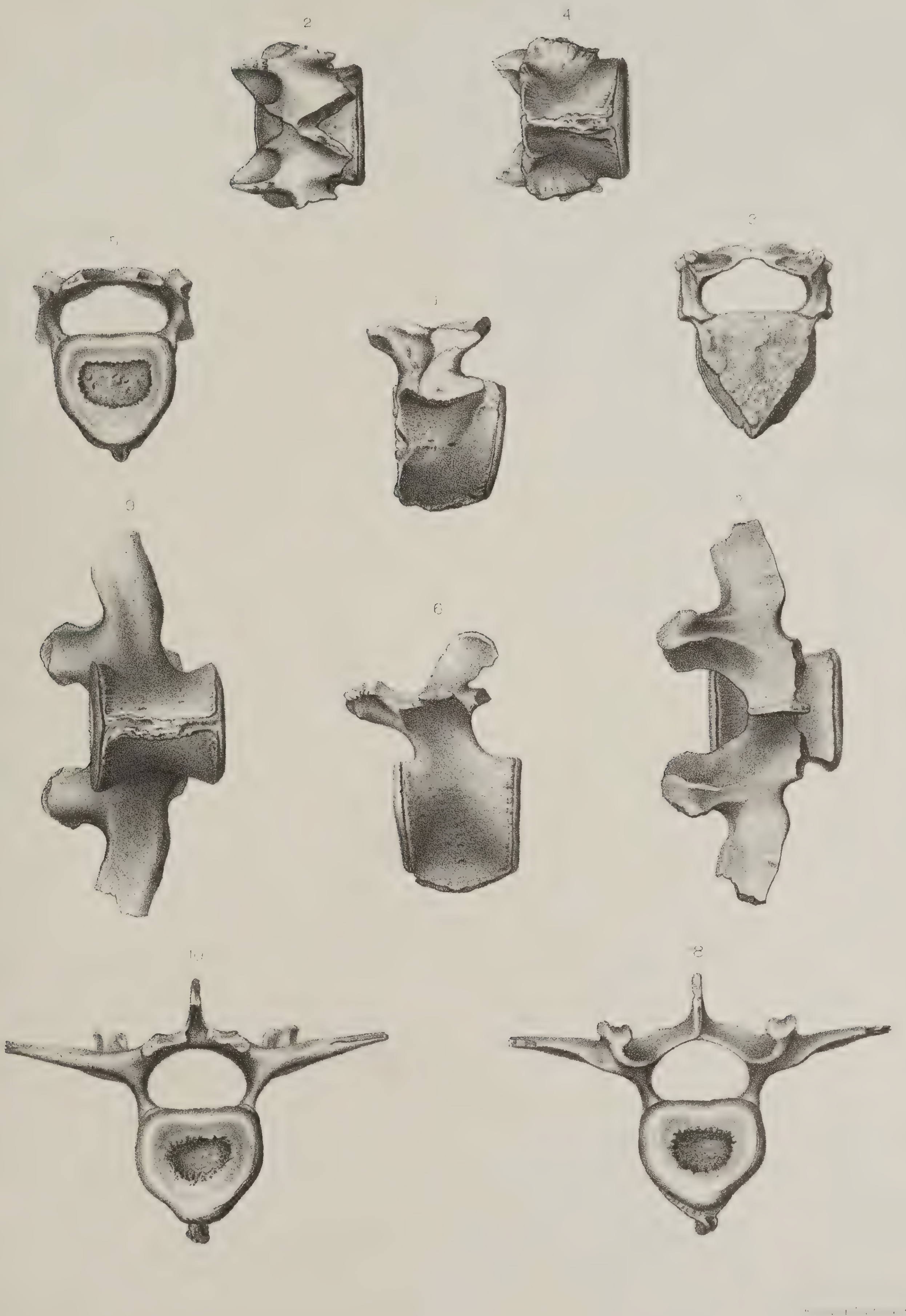
PLATE XXV.

DINOCERATA.

Lumbar Vertebræ of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

PLATE XXV



F. Berger, del.

DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XXVI.

PLATE XXVI.

DINOCERATA.

Lumbar Vertebræ of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

F Berger, del.

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. 1/4.

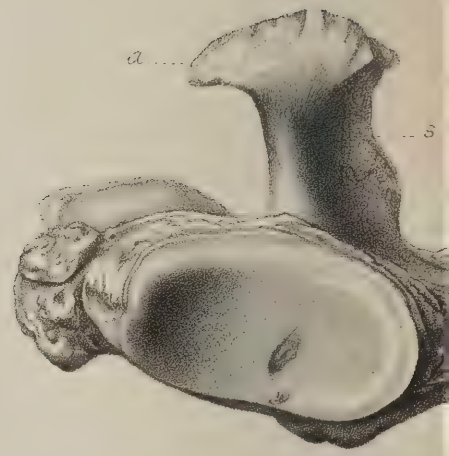
PLATE XXVII.

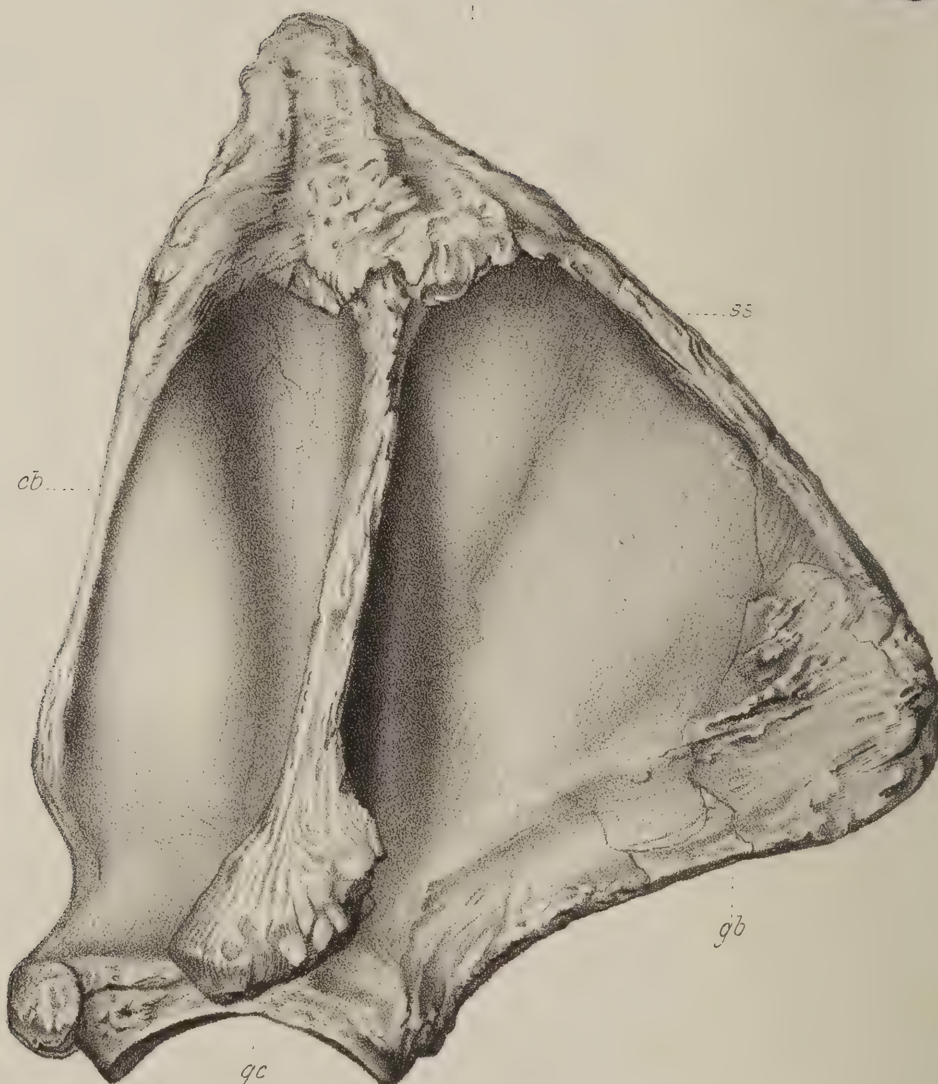
PLATE XXVII.

DINOCERATA.

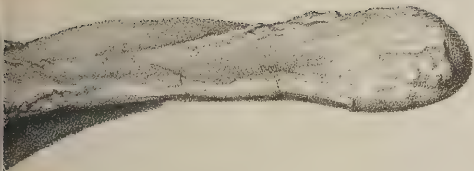
Left Scapula of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.





DINOCERAS MI



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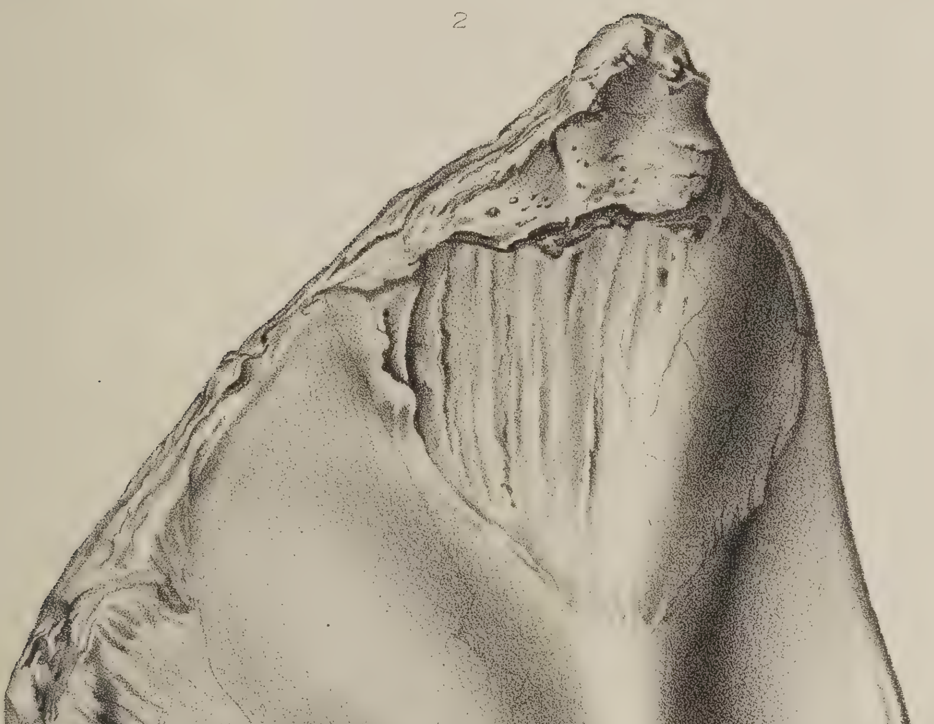


E. Crisand, lith New Haven.

ABILE, Marsh. 1/4.

PLATE XXVIII.

PLATE XXVIII.

DINOCERATA.

Humerus of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

PLATE XXVII.

F Berger, del

E. Crisand, lith New Haven.

DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XXIX.

PLATE XXIX.

DINOCERATA.

Radius of DINOCERAS MIRABILE, Marsh.

F Berger, del

E. Crisand, lith New Haven.

DINOCERAS MIRABILE, Marsh. ¼.

PLATE XXX.

PLATE XXX.

DINOCERATA.

Ulna of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size. Page.

F Berger. del

E. Crisand, lith. New Haven

DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XXXI.

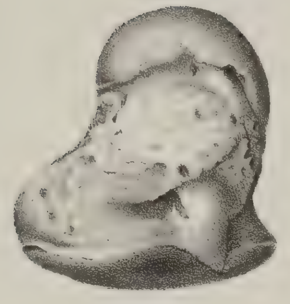
PLATE XXXI.

DINOCERATA.

Scaphoid and Lunar of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size.

1



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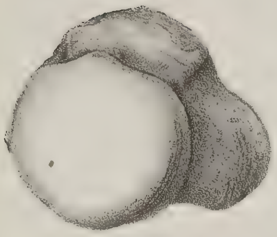
5



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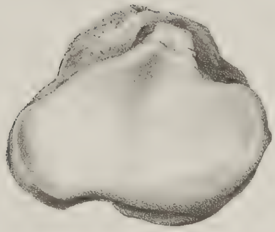

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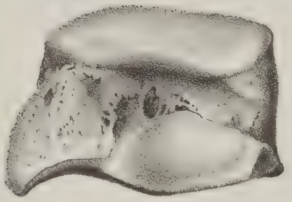

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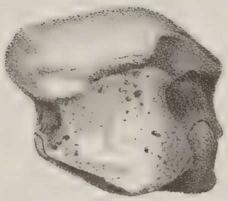

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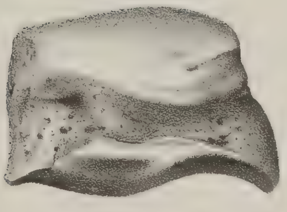


11

12

F Berger, del.

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ½.

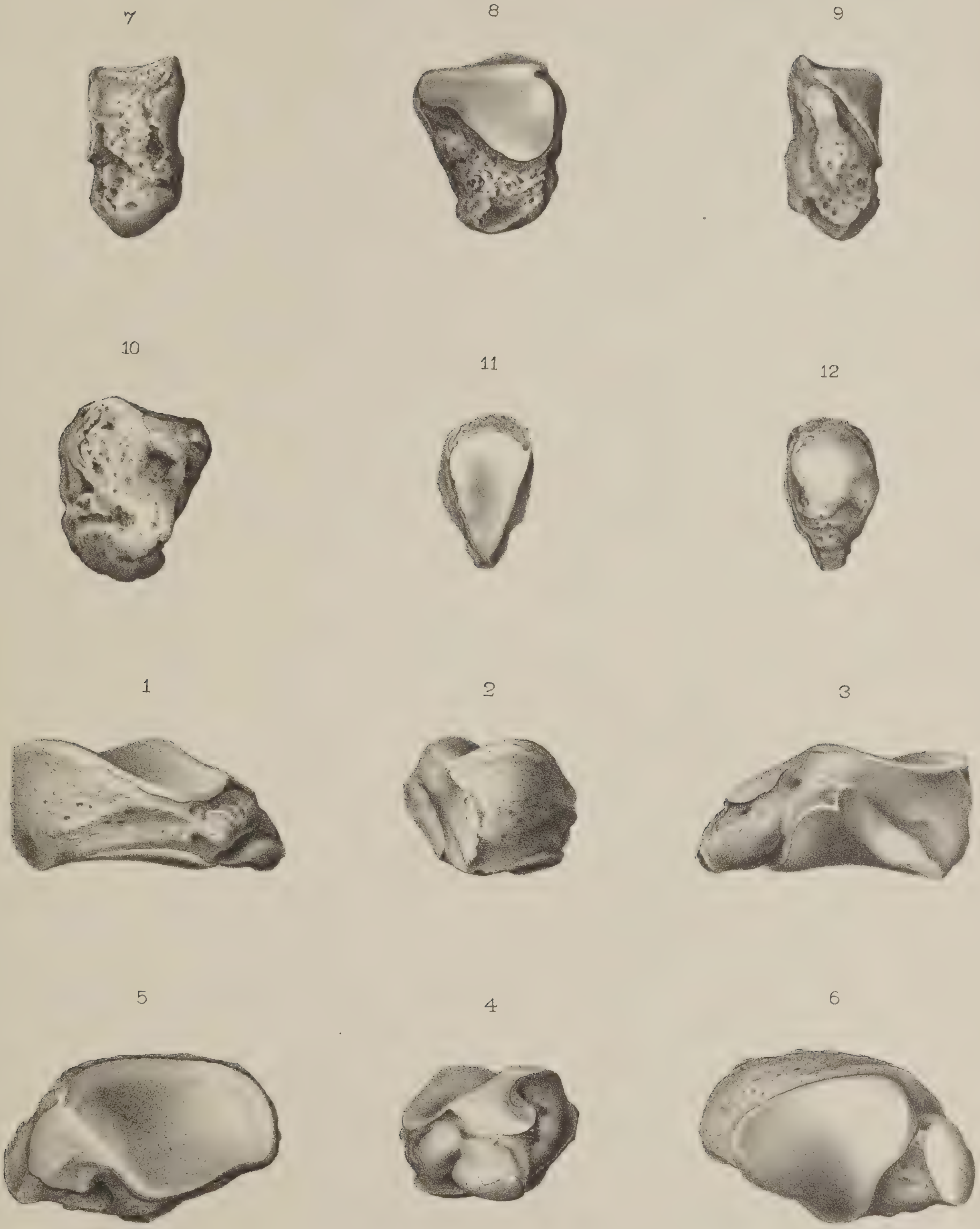
PLATE XXXII.

PLATE XXXII.

DINOCERATA.

Pyramidal and Pisiform of DINOCERAS MIRABILE, MARSH. (Left foot.)

One-half Natural Size.



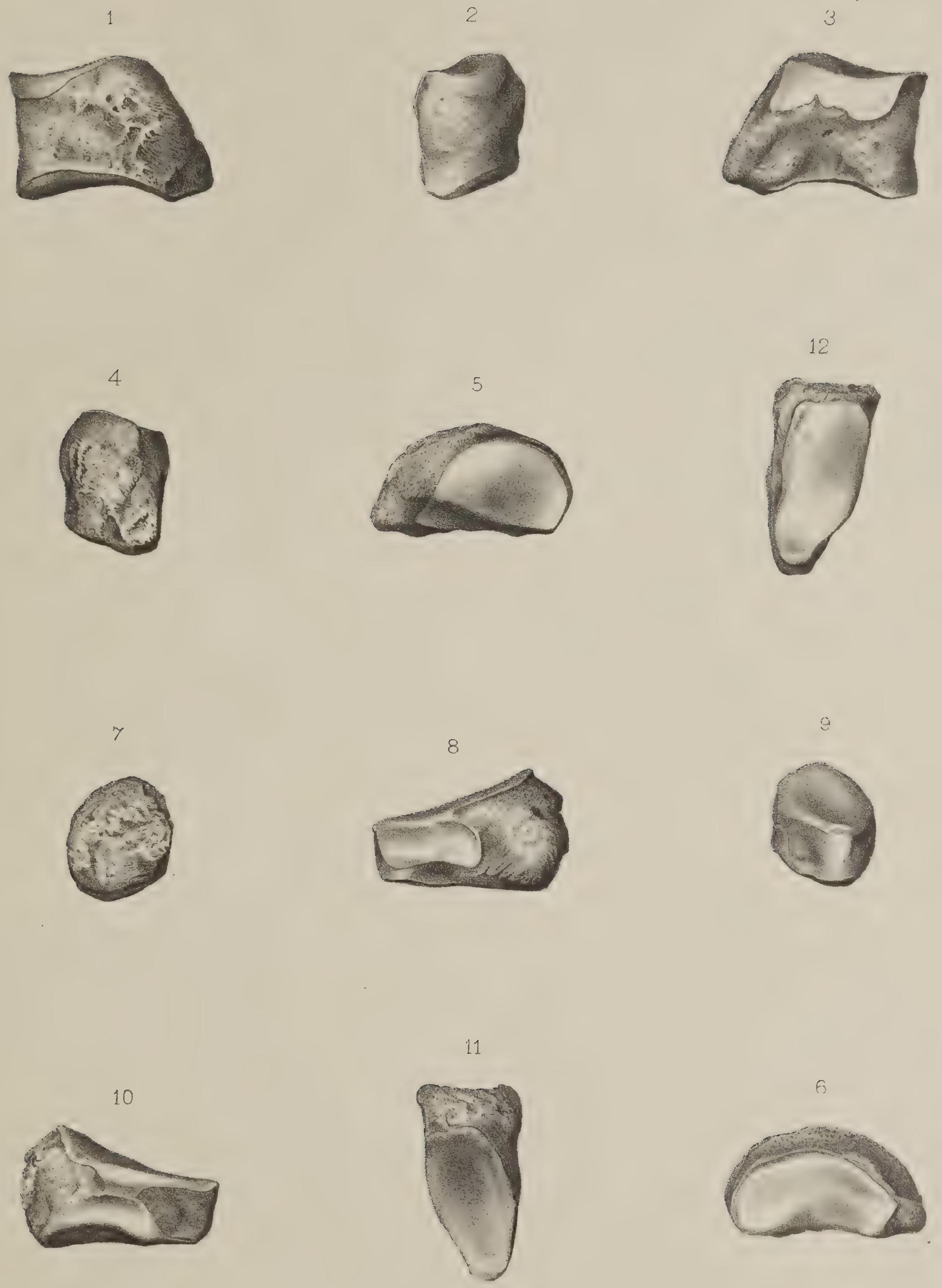
DINOCERAS MIRABILE, Marsh. ½.

PLATE XXXIII.

PLATE XXXIII.

DINOCERATA.

Trapezium and Trapezoid of DINOCERAS MIRABILE, Marsh. (Left foot.)



F Berger, del. E. Crisand, lith New Haven.

DINOCERAS MIRABILE, Marsh. ½.

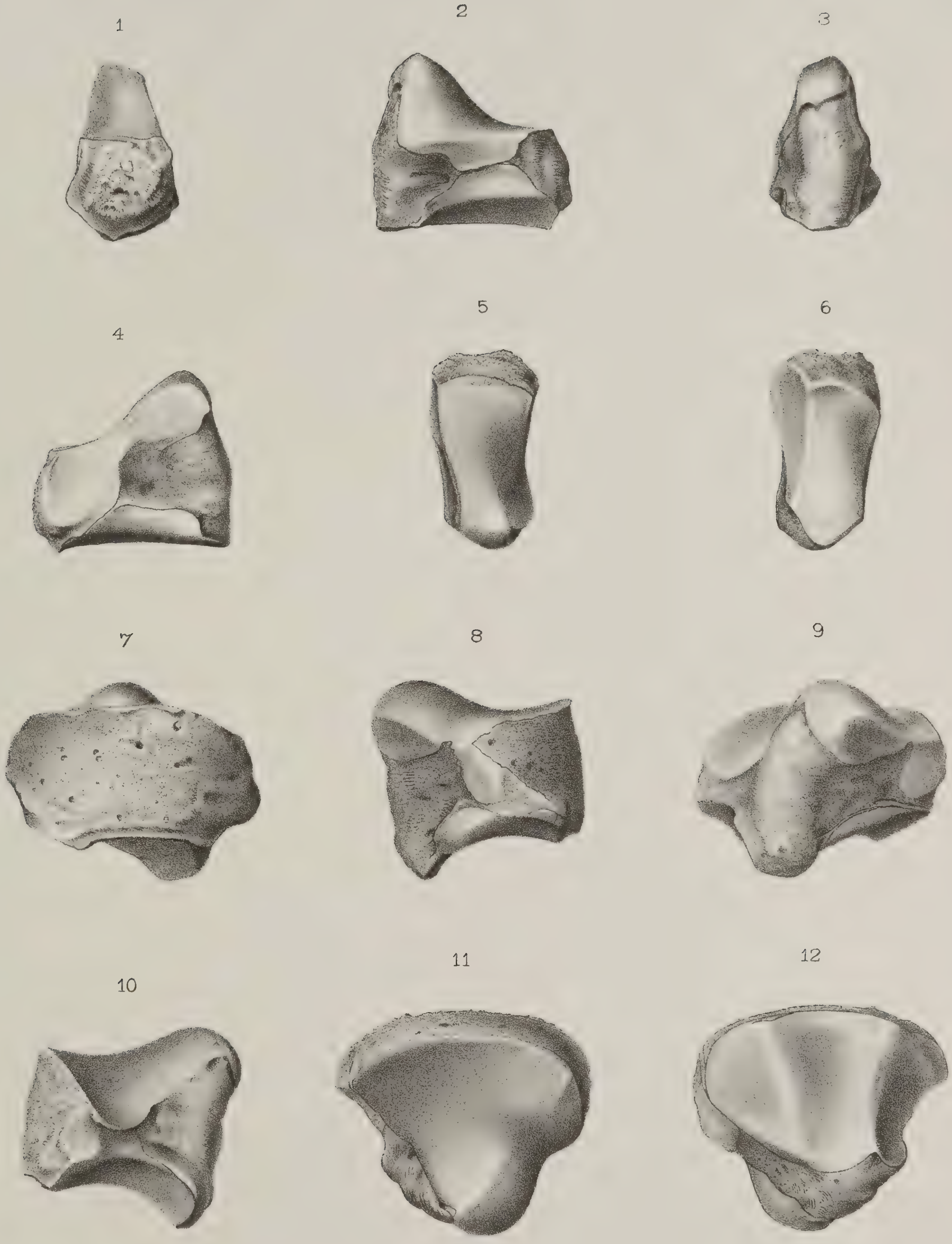
PLATE XXXIV.

PLATE XXXIV.

DINOCERATA.

Magnum and Unciform of DINOCERAS MIRABILE, **Marsh.** (Left foot.)

One-half Natural Size.



DINOCERAS MIRABILE, Marsh. ½.

PLATE XXXV.

PLATE XXXV.

DINOCERATA.

Metacarpals of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size.

F. Berger, del.

E. Crisand, lith. New Haven

DINOCERAS MIRABILE, Marsh. ½.

PLATE XXXVI.

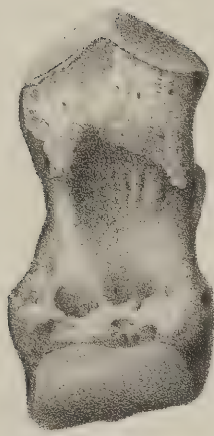
PLATE XXXVI.

DINOCERATA.

Metacarpals of DINOCERAS MIRABILE Marsh. (Left foot.)

One-half Natural Size.

1



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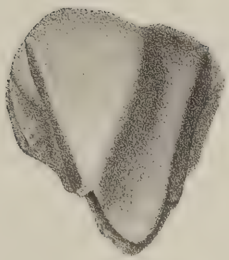

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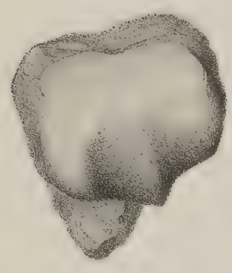

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4

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F Berger, del

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ½.

PLATE XXXVII.

PLATE XXXVII.

DINOCERATA.

Metacarpals of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size.

DINOCERAS MIRABILE, Marsh ½

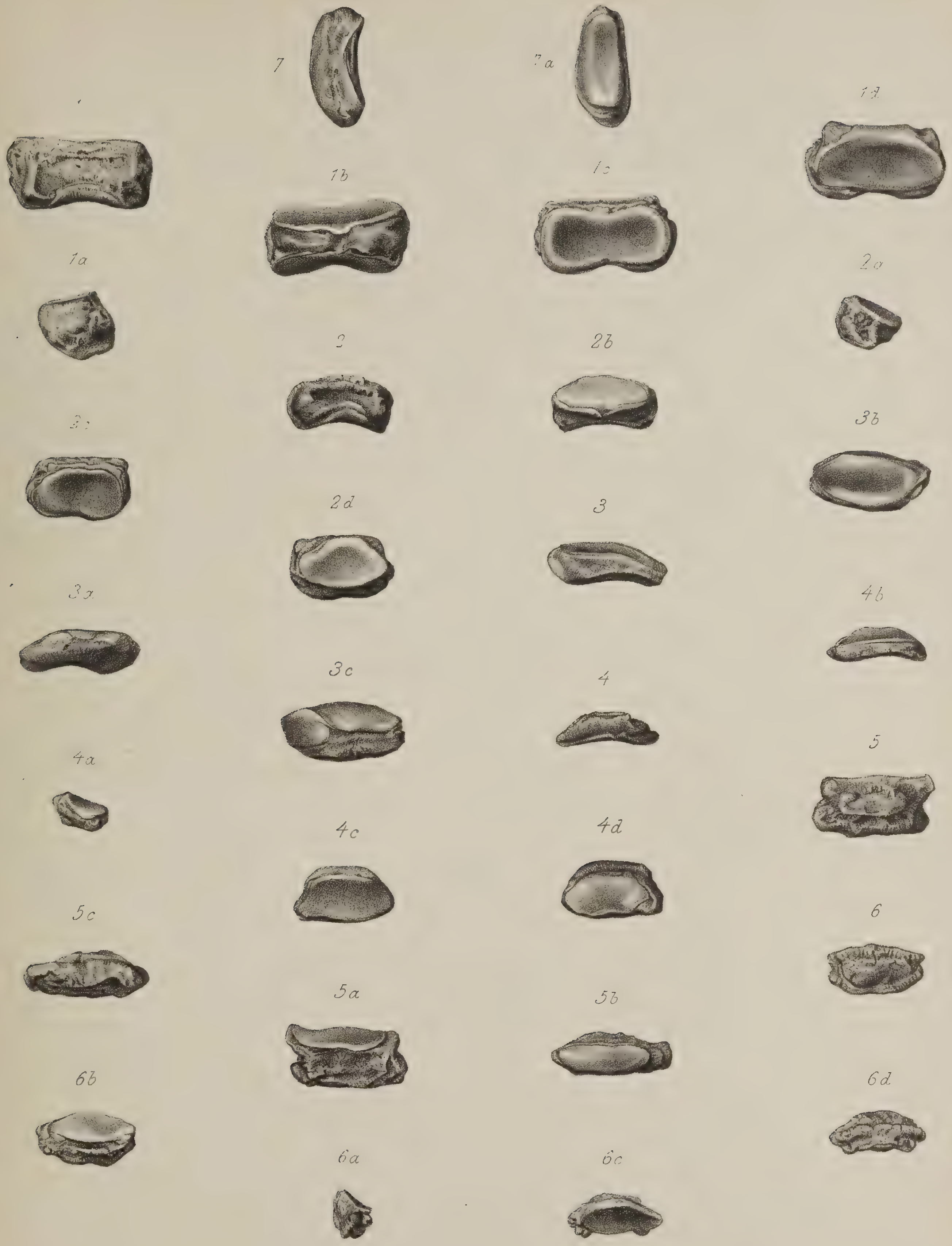
PLATE XXXVIII.

PLATE XXXVIII.

DINOCERATA.

Phalanges of DINOCERAS MIRABILE, **Marsh.**

One-half Natural Size.



F Berger, del.

E. Crisand, lith. New Haven

DINOCERAS MIRABILE, Marsh. ½.

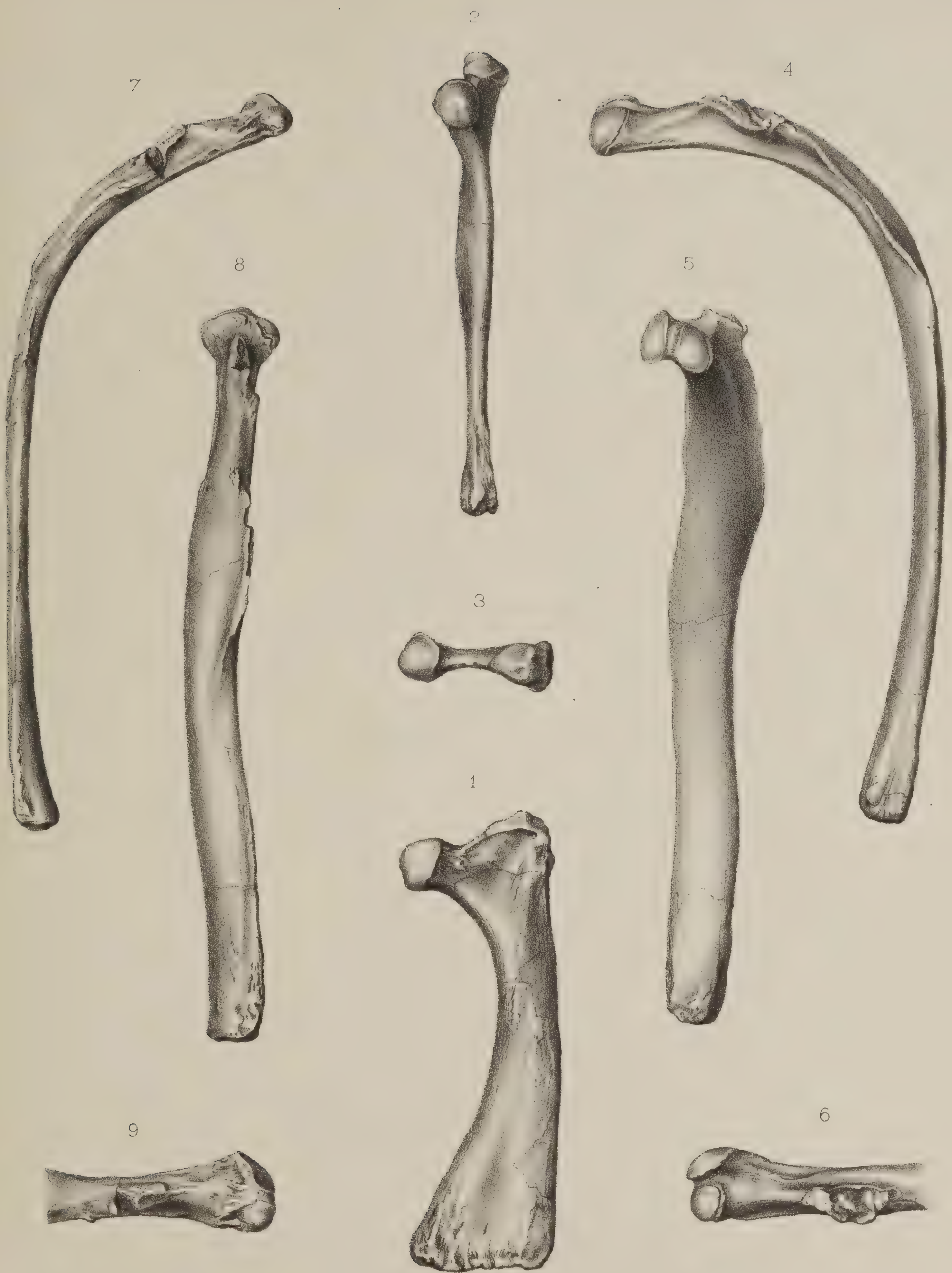
PLATE XXXIX.

PLATE XXXIX.

DINOCERATA.

Ribs of Dinoceras mirabile, **Marsh.**

One-fourth Natural Size.



F Berger, del

E. Crisand, lith New Haven.

DINOCERAS MIRABILE, Marsh. 1/4.

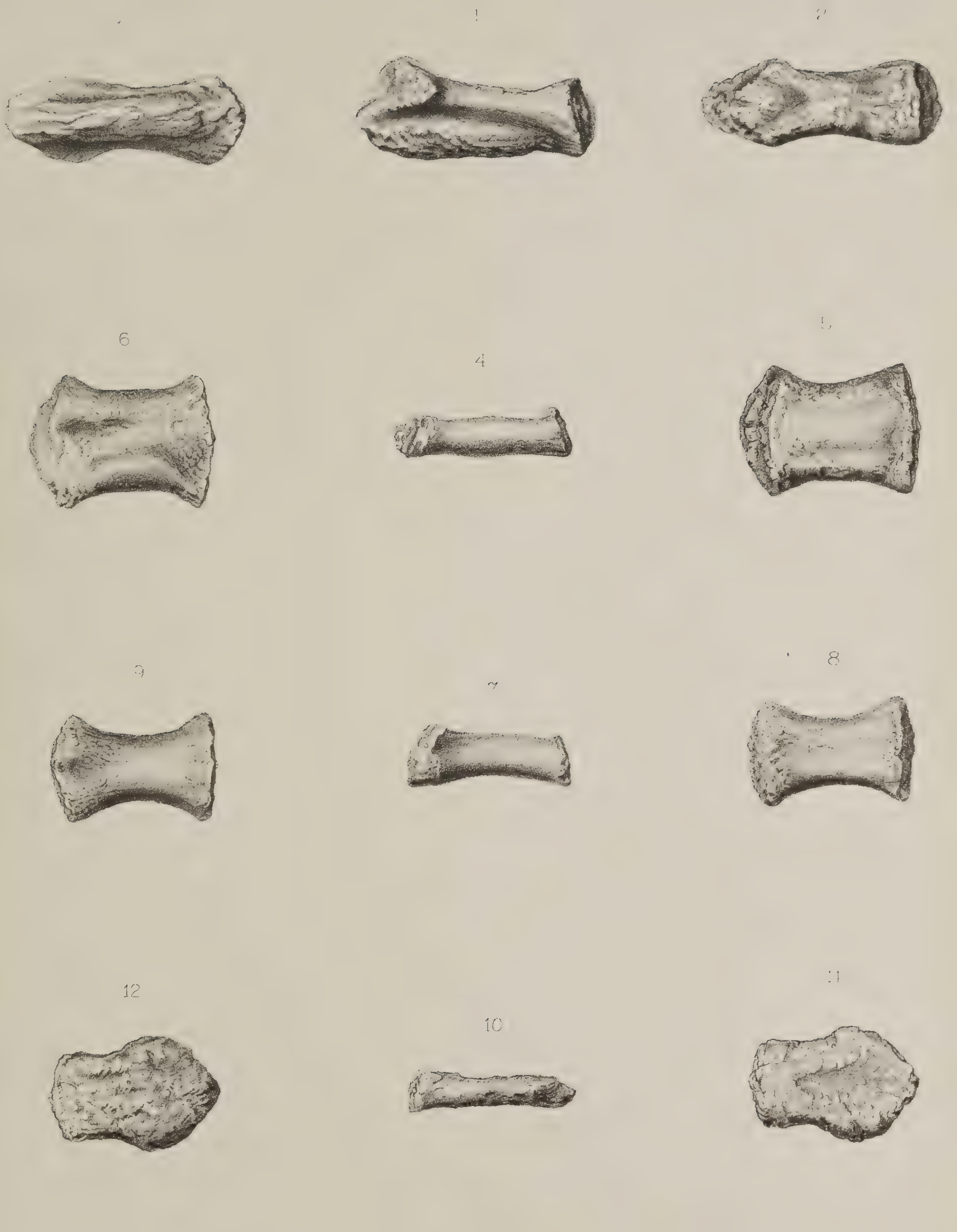
PLATE XL.

PLATE XL.

DINOCERATA.

Sternum of DINOCERAS MIRABILE, **Marsh.**

One-fourth Natural Size. Page.



F. Berger, del.

E. Crisand, lith. New Haven.

DINOCERAS MIRABILE, Marsh. ¼.

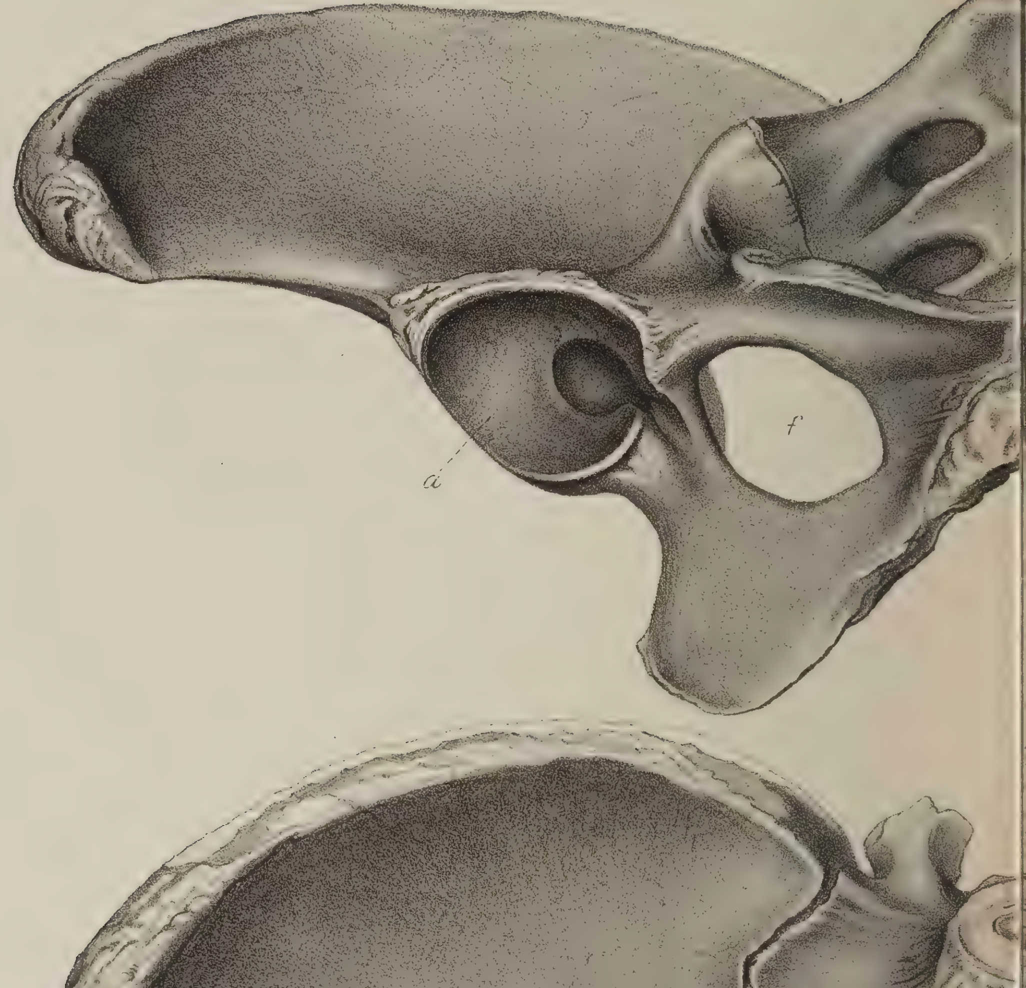
PLATE XLI.

PLATE XLI.

DINOCERATA.

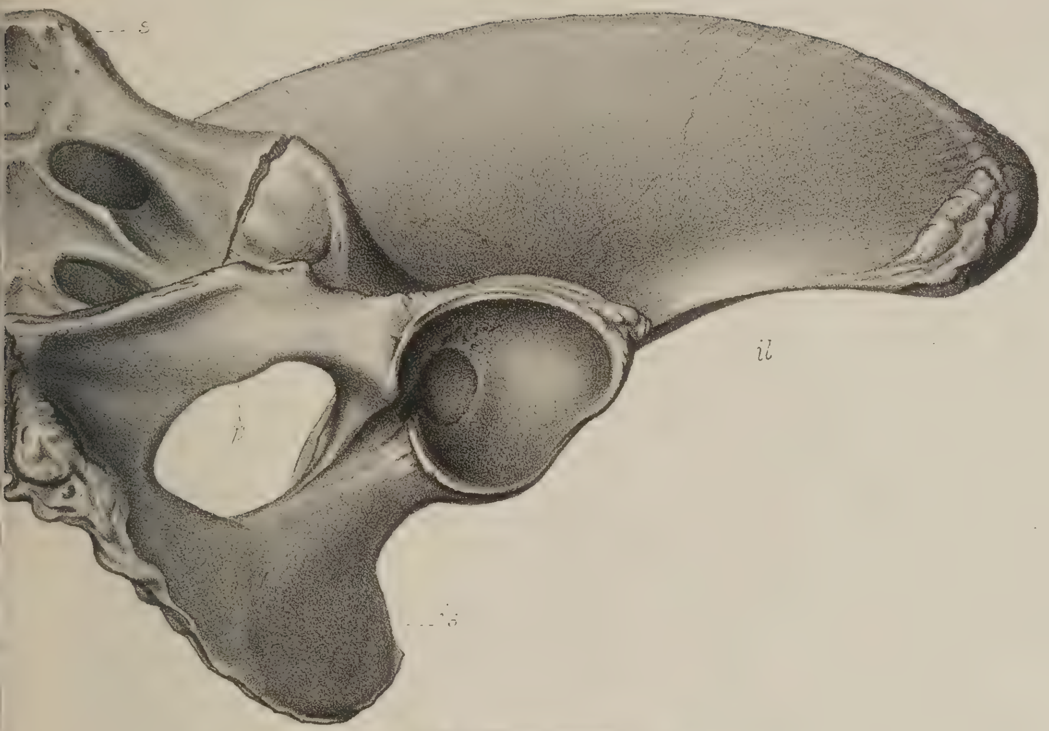
Pelvis of DINOCERAS MIRABILE, Marsh.

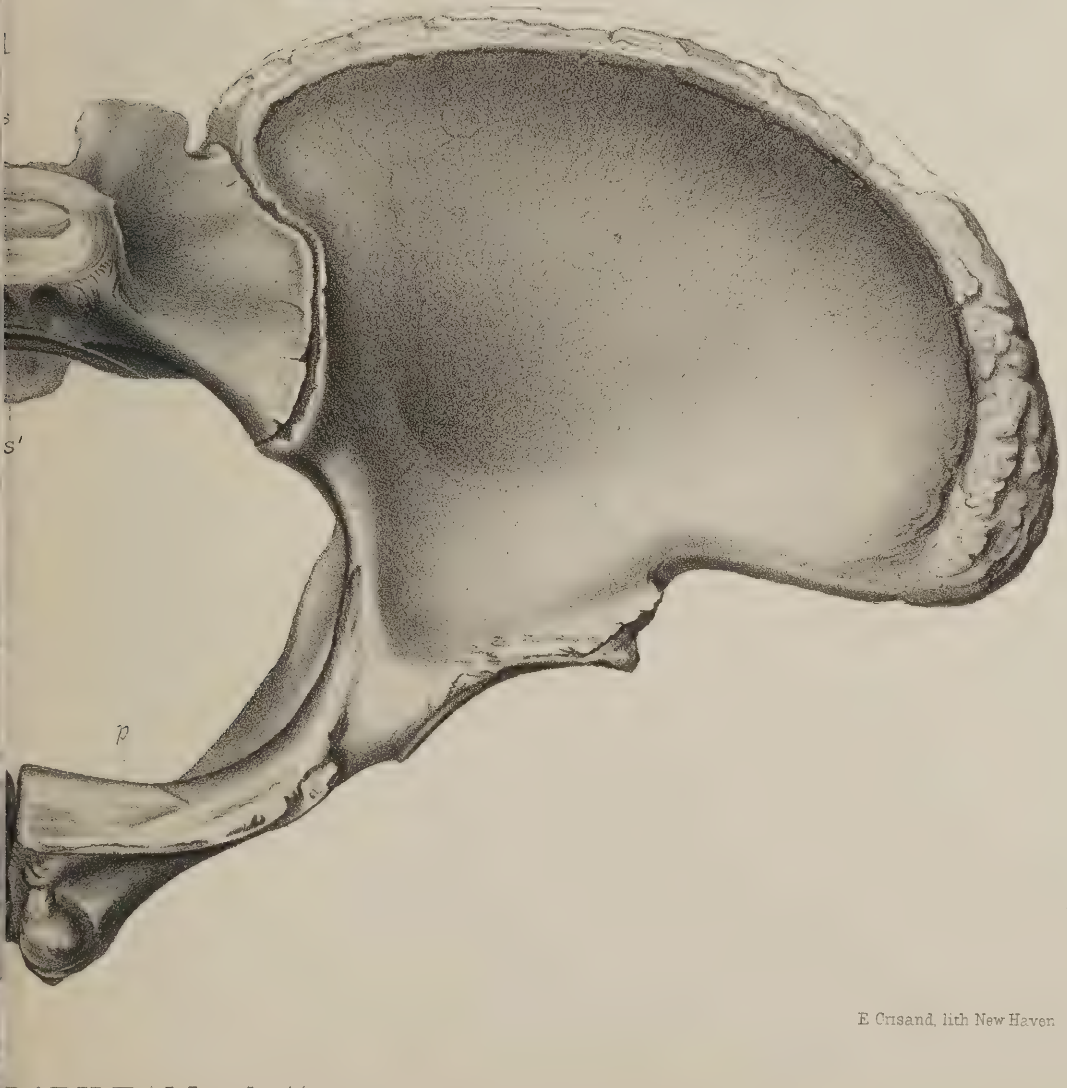
a —Acetabulum.
f —Obturator foramen.
il —Ilium.
is —Ischium.
p —Pubis.
s —Anterior end of sacrum.
s′ —Posterior end of sacrum.



F Berger, del.

DINOCERAS M





E Crisand, lith New Haven.

RABILE, Marsh. 1/4.

PLATE XLII.

PLATE XLII.

DINOCERATA.

Pelvis of DINOCERAS MIRABILE, Marsh

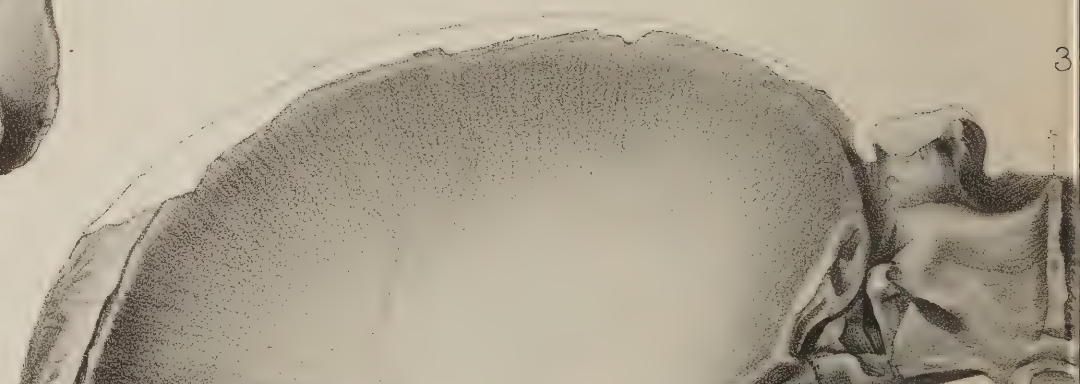
One-fourth Natural Size.

a —Acetabulum.
f —Obturator foramen.
i —Sacral face for ilium.
il—Ilium.
is—Ischium.
p —Pubis.
s —Anterior end of sacrum.
s′ —Posterior end of sacrum

2

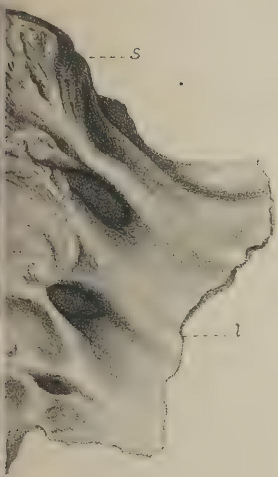
4

3



F Berger, del

DINOCERAS MIRA



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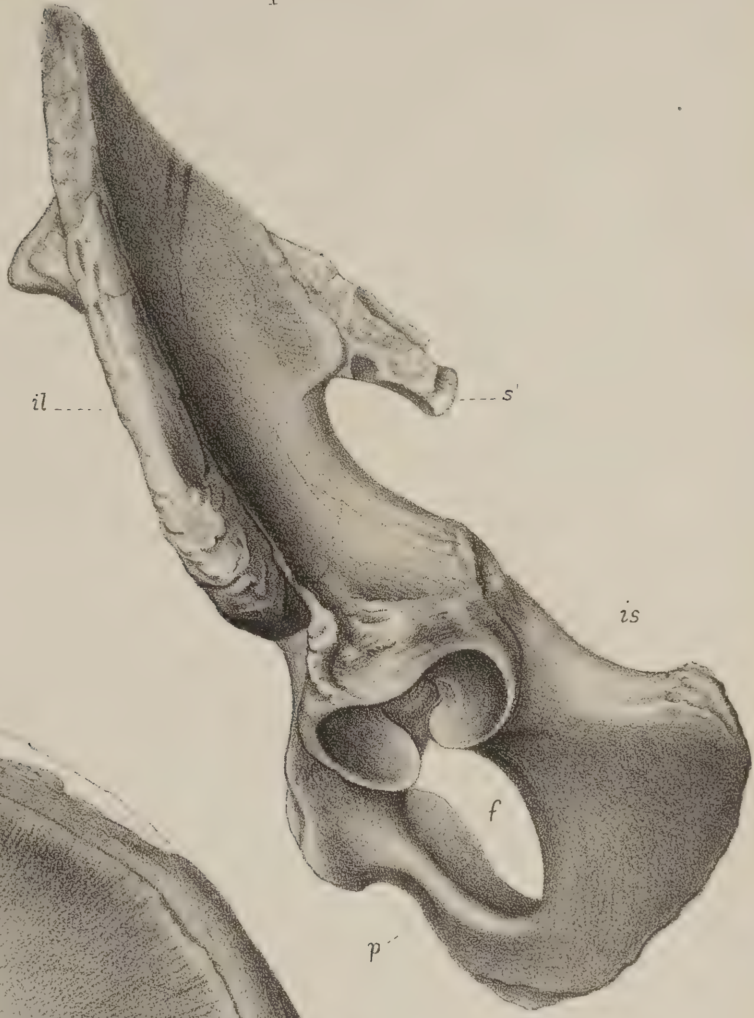
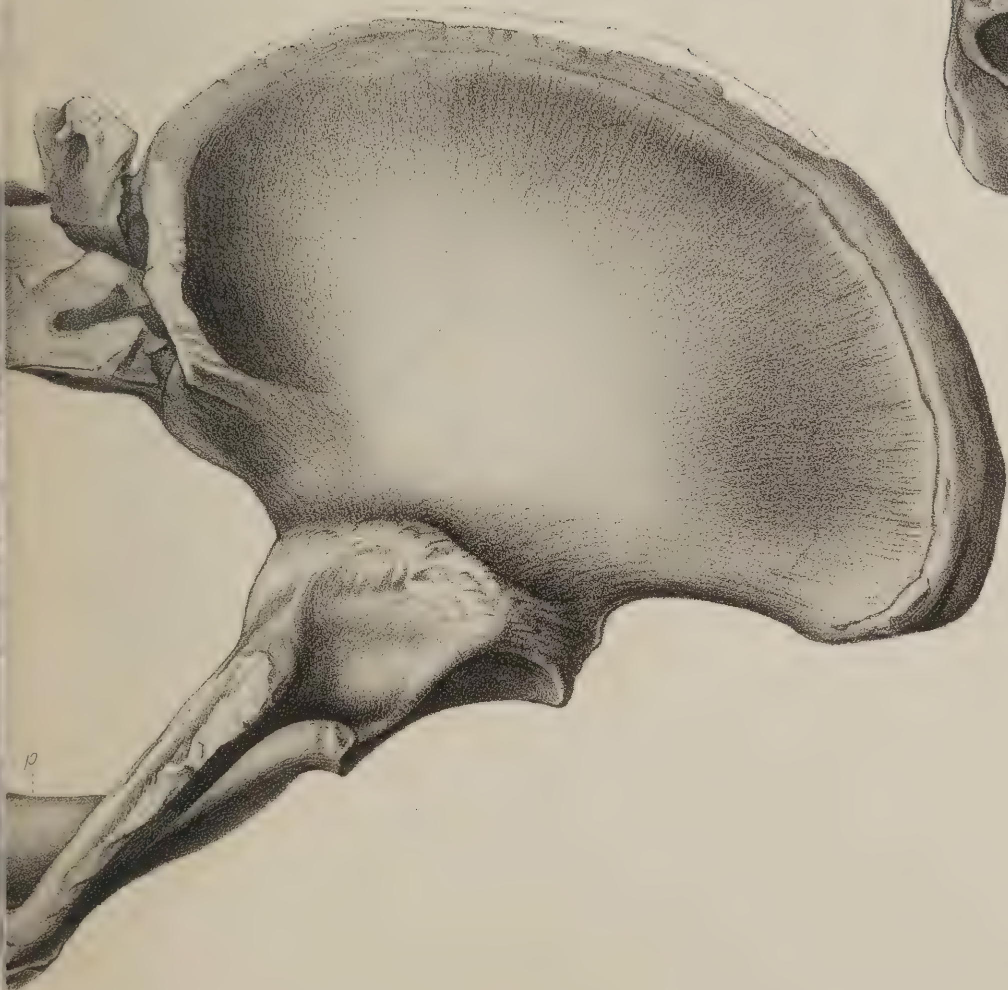




E Crisand, lith New Haven.

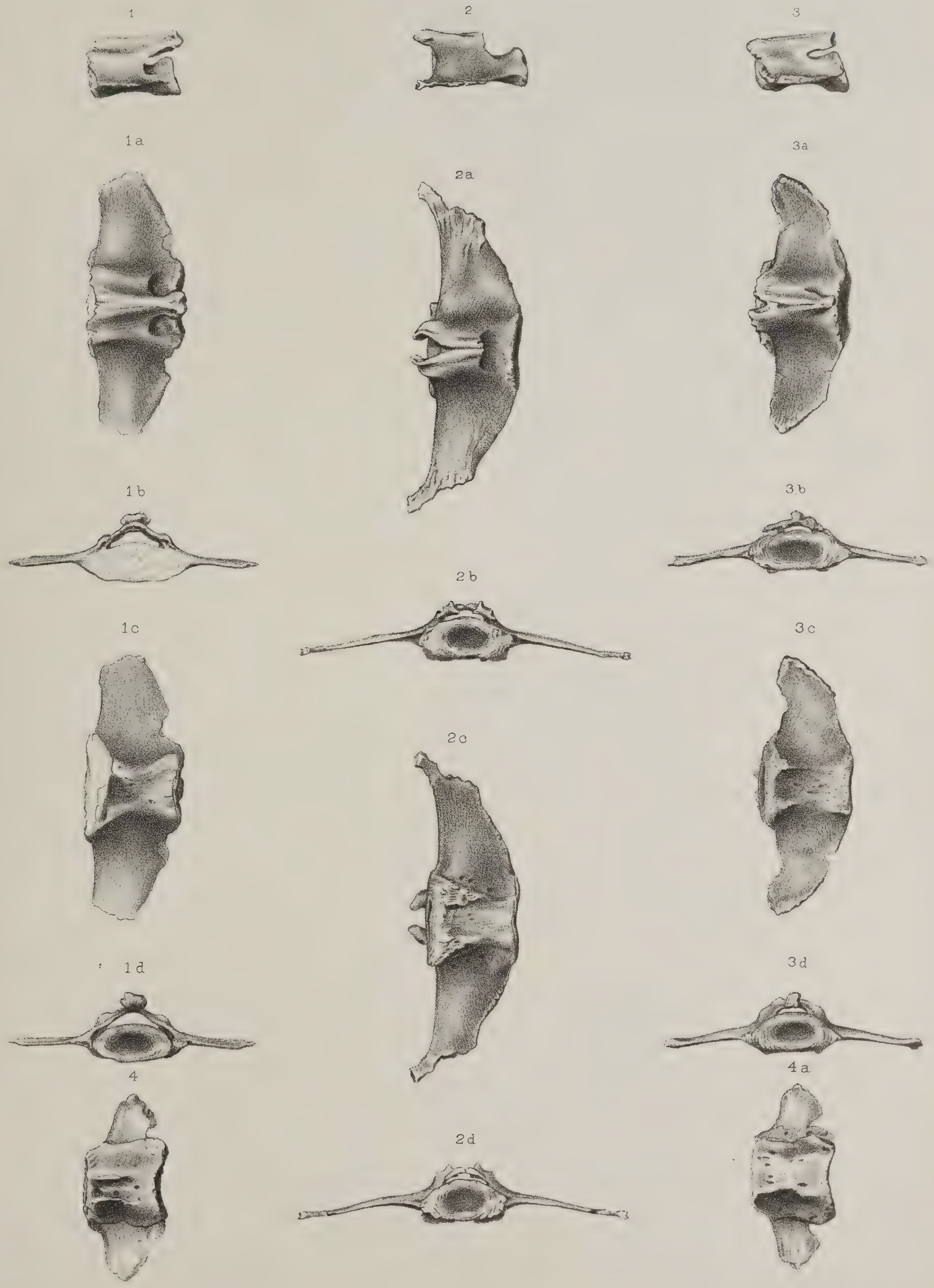
ILE, Marsh. 1/4.

PLATE XLIII.

PLATE XLIII.

DINOCERATA.

Caudal Vertebræ of DINOCERAS LATICEPS, **Marsh.**



DINOCERAS LATICEPS, Marsh. ¼.

PLATE XLIV.

PLATE XLIV.

DINOCERATA.

Femur of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size. Page.

FIG. 1.—Left Femur; front, or superior, view, -- 139

t —Great trochanter.

t' —Lesser trochanter.

1*a*—Distal end.

Fig. 2.—The same; inner view, -- 139

FIG. 3.—The same; back, or inferior, view, -- 139

3*a*—Proximal end.

F. Berger, del.

E. Crisand, lith. New Haven.

DINOCERAS MIRABILE, Marsh. ¼.

PLATE XLV.

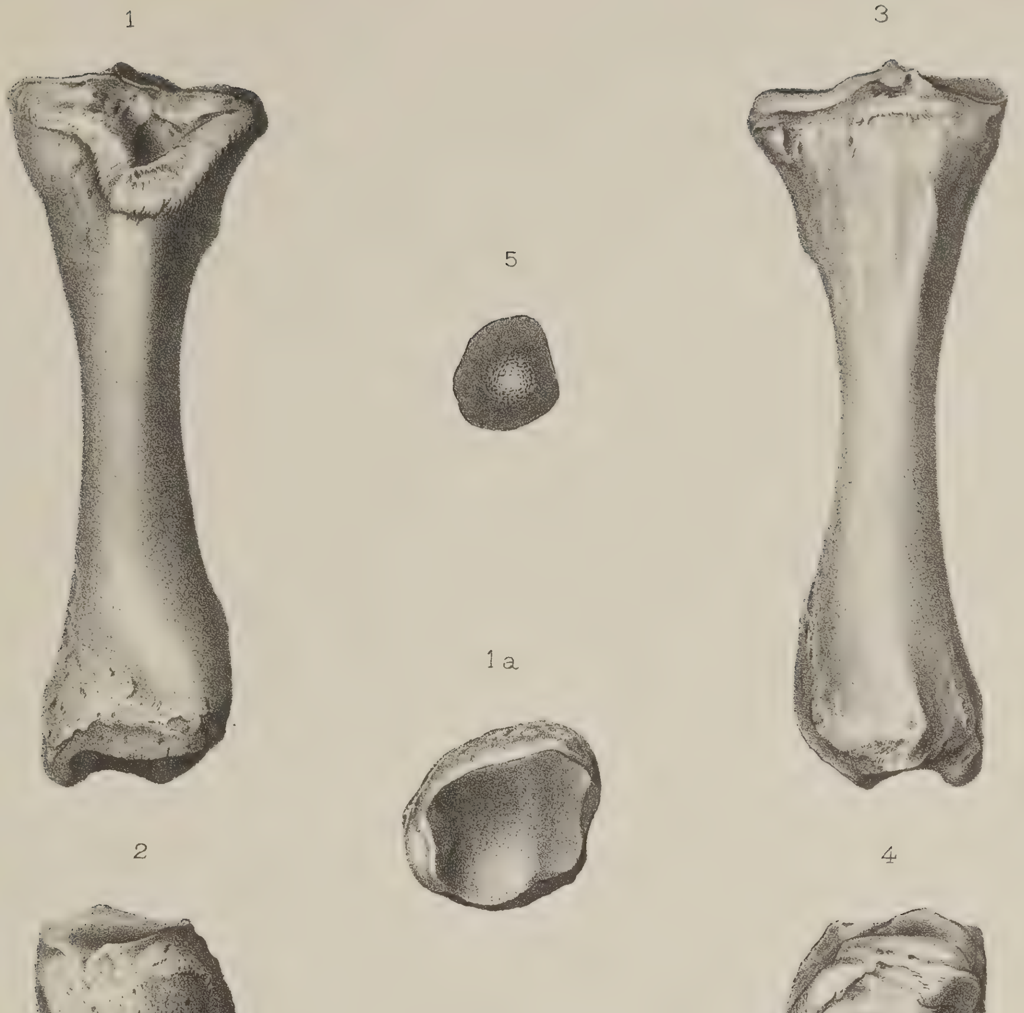
PLATE XLV.

DINOCERATA.

Tibia of DINOCERAS MIRABILE, Marsh.

One-fourth Natural Size.

PLATE. X[illegible]



DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XLVI.

PLATE XLVI.

DINOCERATA.

Fibula and Patella of DINOCERAS MIRABILE, Marsh.

F Berger, del

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. 1/4.

PLATE XLVII.

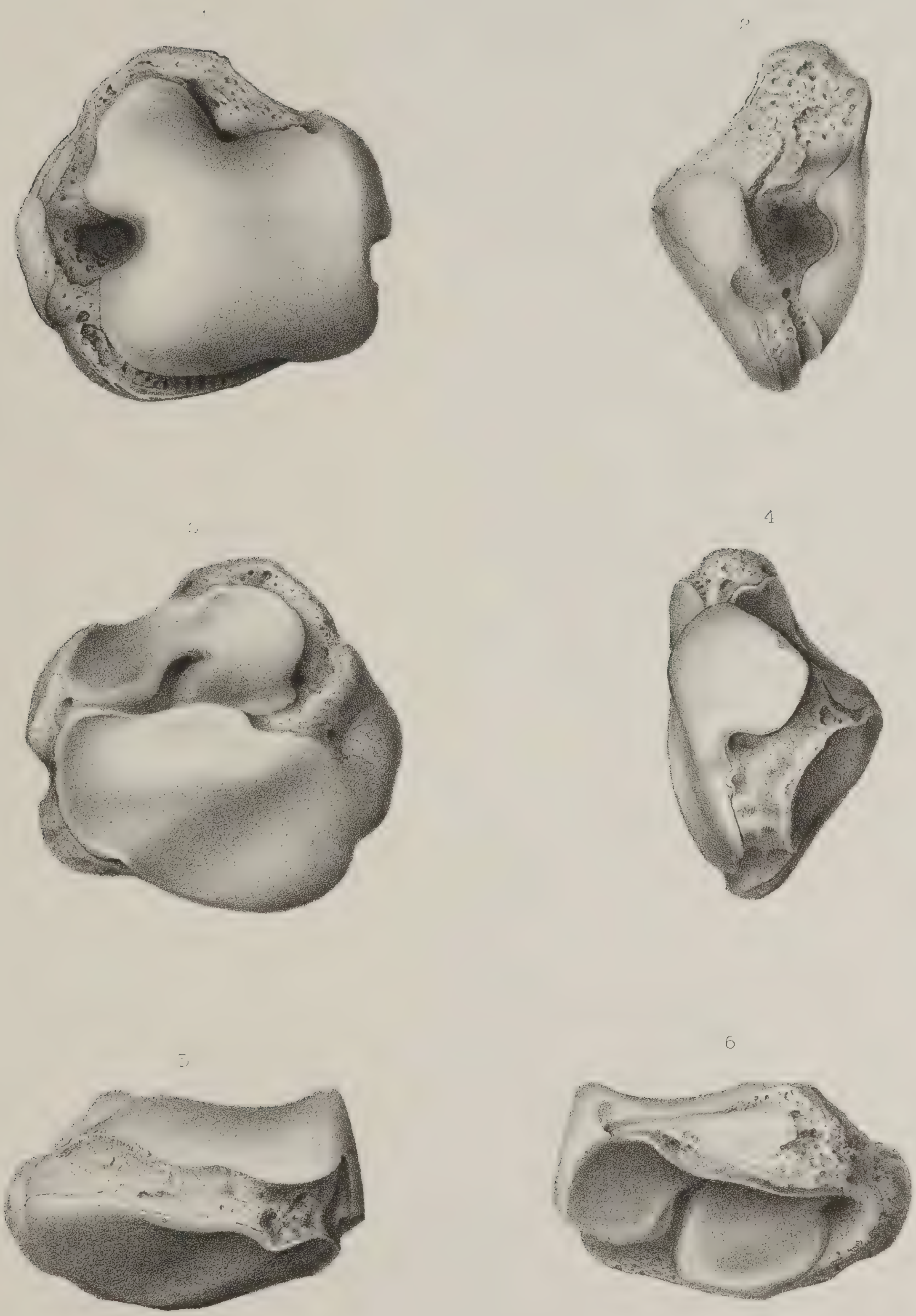
PLATE XLVII.

DINOCERATA.

Astragalus of Dinoceras mirabile, Marsh. (Left foot.)

One-half Natural Size.

	Page.
Fig. 1.—Astragalus; superior view, showing face for articulation with tibia,	146
Fig. 2.—The same; lateral view, tibial side,	146
Fig. 3.—The same; inferior view,	146
Fig. 4.—The same; lateral view, fibular side,	146
Fig. 5.—The same; front view,	146
Fig. 6.—The same; posterior view,	146



DINOCERAS MIRABILE, Marsh. 1/2.

PLATE XLVIII.

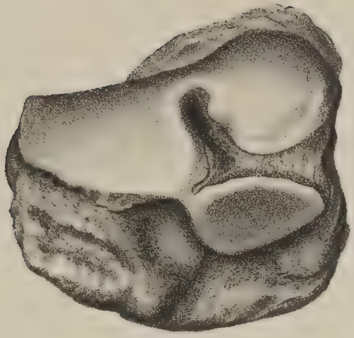
PLATE XLVIII.

DINOCERATA.

Calcaneum of DINOCERAS MIRABILE, Marsh (Left foot.)

One-half Natural Size.

1



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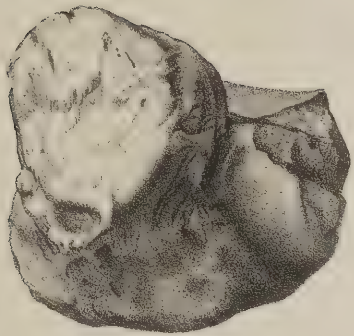

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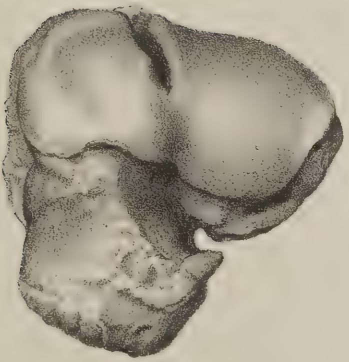

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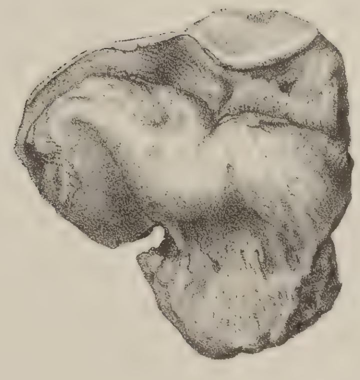


F Berger, del.

E. Crisand, lith. New Haven

DINOCERAS MIRABILE, Marsh. ½.

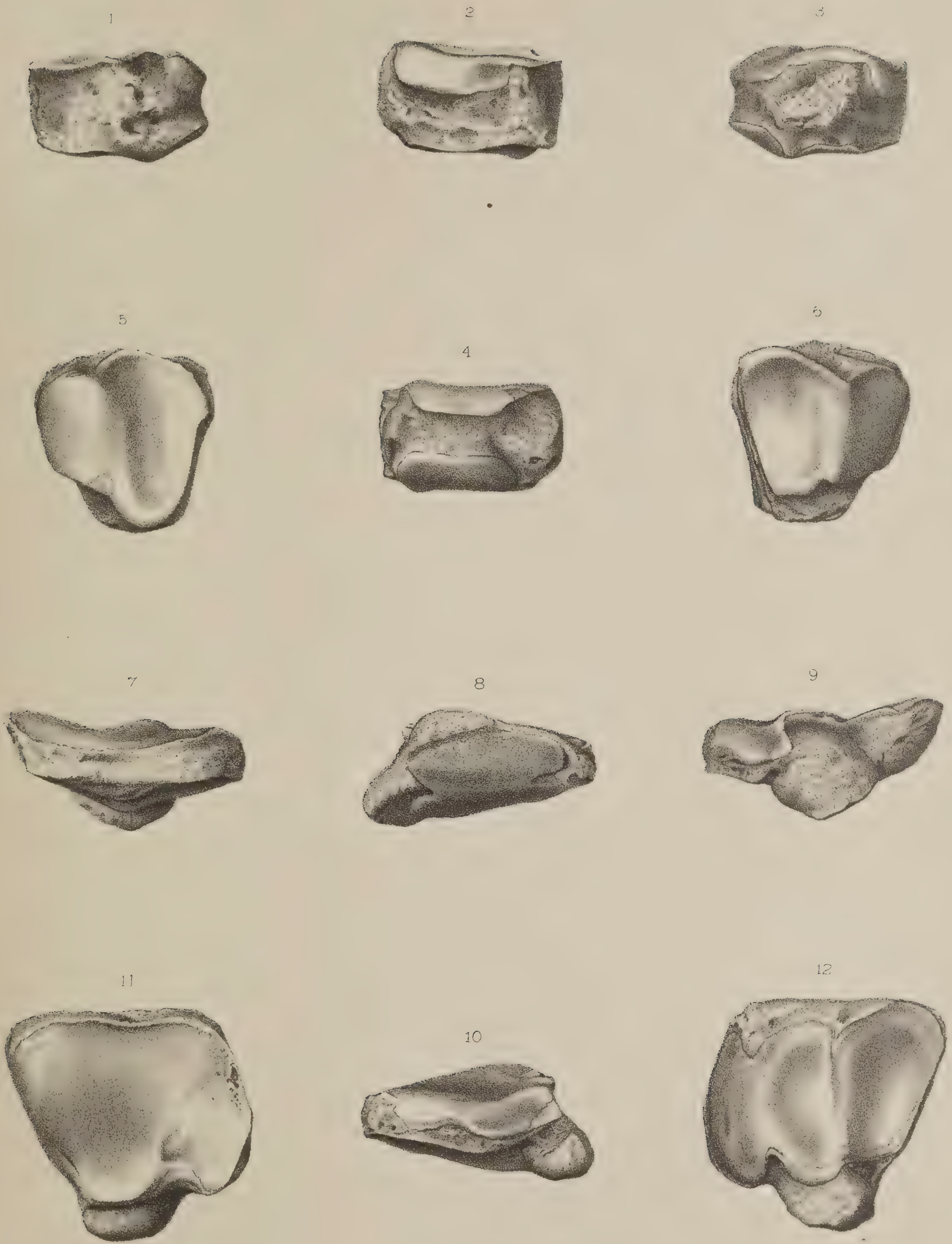
PLATE XLIX.

PLATE XLIX.

DINOCERATA.

Cuboid and Navicular of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size.



F. Berger, del. E. Crisand, lith. New Haven.

DINOCERAS MIRABILE, Marsh. 1/2.

PLATE L.

PLATE L.

DINOCERATA.

Tarsal bones of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size.

F. Berger, del.

E. Crisand, lith New Ha

DINOCERAS MIRABILE, Marsh. ½.

PLATE LI.

PLATE LI.

DINOCERATA.

Metatarsals of DINOCERAS MIRABILE, Marsh. (Left foot.)

One-half Natural Size. Page.

PLATE LI.

F Berger, del

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ½.

PLATE LII.

PLATE LII.

DINOCERATA.

Metatarsals of Dinoceras mirabile, Marsh. (Left foot.)

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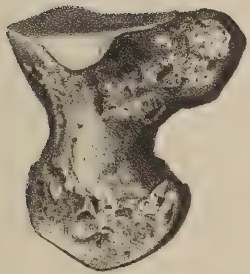

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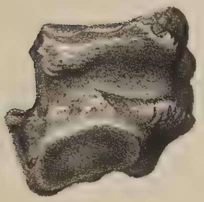

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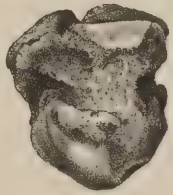

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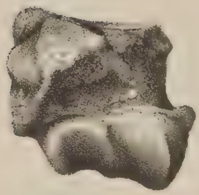

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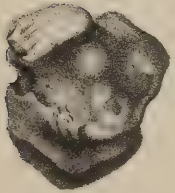

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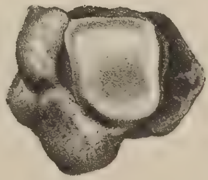

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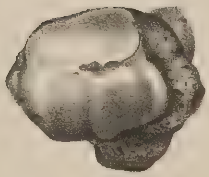


F Berger, del.

E. Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ½.

PLATE LIII.

PLATE LIII.

DINOCERATA.

Phalanges of DINOCERAS MIRABILE, Marsh.

One-half Natural Size. Page.

FIG. 1.—Proximal phalanx of median digit; front view, 164
- 1*a* —Lateral view.
- 1*b* —Posterior view.
- 1*c* —Proximal end.
- 1*d* —Distal end.

FIG. 2.—Proximal phalanx; front view, 164
- 2*a* —Posterior view.
- 2*b* —Proximal end.
- 2*c* —Distal end.

FIG. 3.—Proximal phalanx of lateral digit; front view, 164
- 3*a* —Posterior view.
- 3*b* —Proximal end.
- 3*c* —Distal end.

FIG. 4.—Median phalanx; front view, 164
- 4*a* —Posterior view.
- 4*b* —Proximal end.
- 4*c* —Distal end.

FIG. 5.—Median phalanx; front view, 164
- 5*a* —Proximal end.
- 5*b* —Distal end.

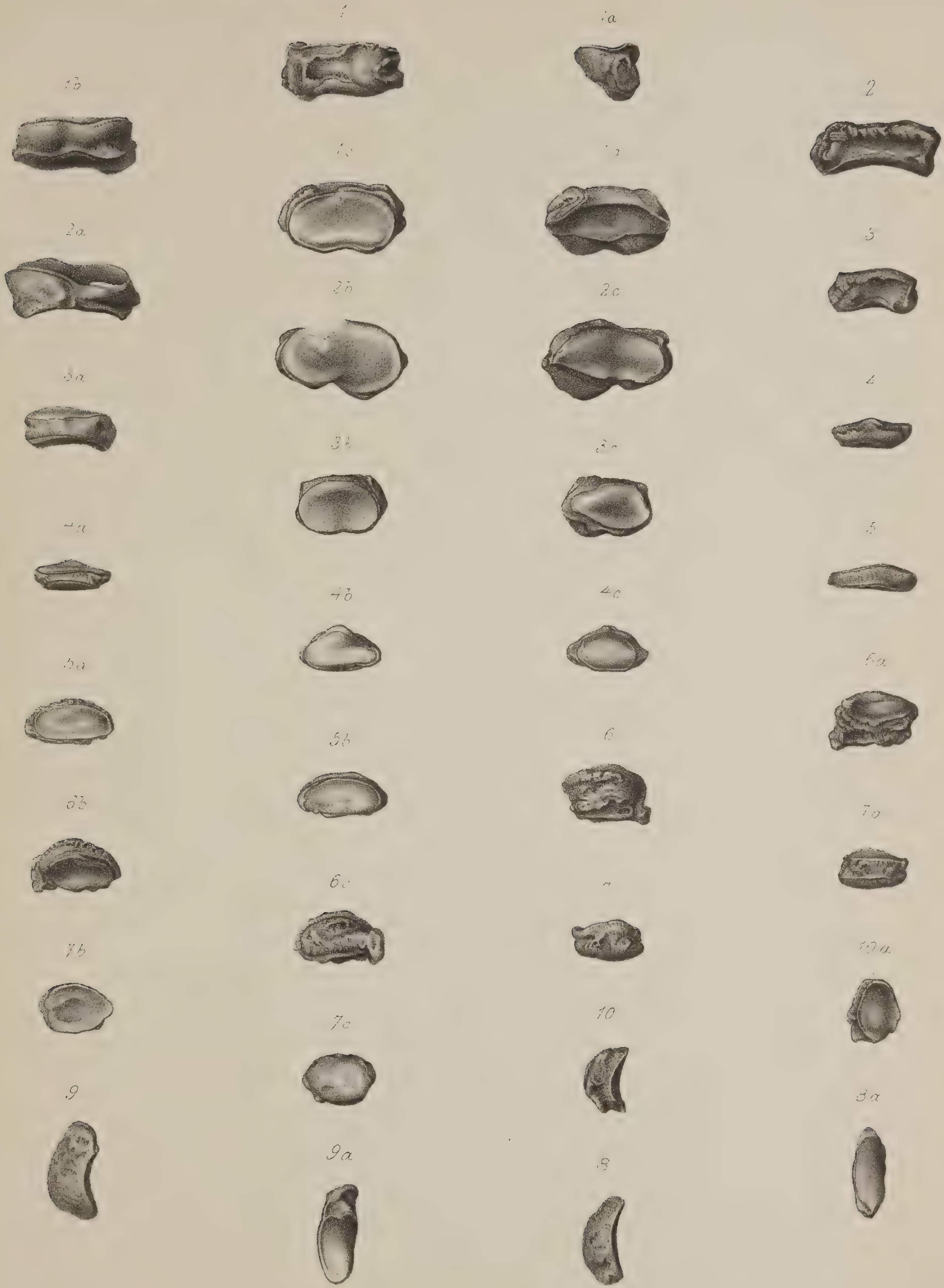
FIG. 6.—Ungual phalanx; front view, 164
- 6*a* —Posterior view.
- 6*b* —Proximal end.
- 6*c* —Distal end.

FIG. 7.—Ungual phalanx; front view, 164
- 7*a* —Posterior view.
- 7*b* —Proximal end.
- 7*c* —Distal end.

FIG. 8.—Sesamoid bone from metatarso-phalangeal articulation; lateral view, 164
- 8*a* —Articular surface.

FIG. 9.—Sesamoid bone from metatarso-phalangeal articulation; lateral view, 164
- 9*a* —Articular surface.

FIG. 10.—Sesamoid bone, probably from hallux; lateral view, 164
- 10*a*—Articular surface.



F Berger, del

E Crisand, lith New Haven

DINOCERAS MIRABILE, Marsh. ½.

PLATE LIV.

PLATE LIV.

DINOCERATA.

Feet of DINOCERAS MIRABILE, Marsh.

One-half Natural Size.

Page.

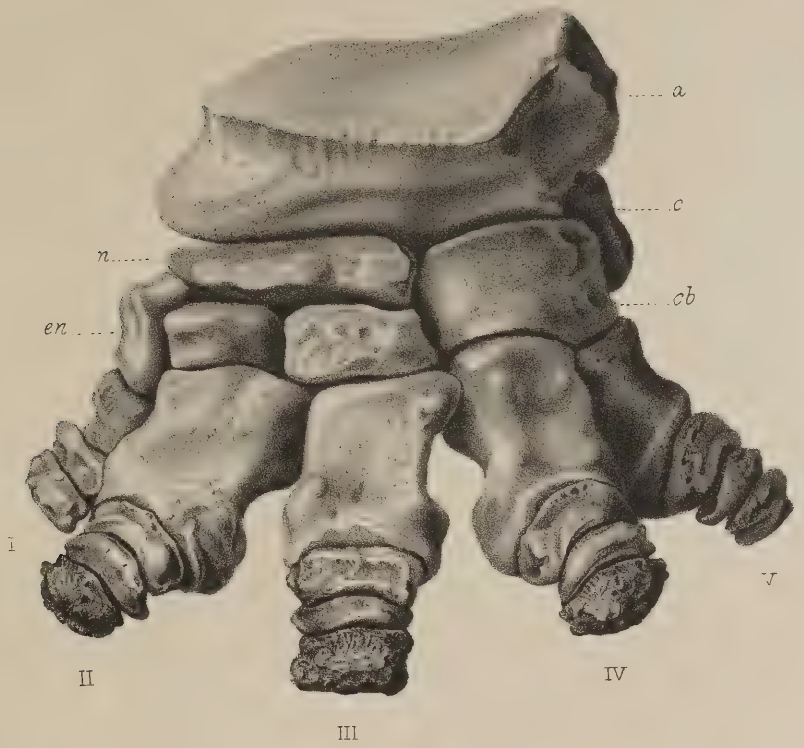
FIG. 1.—Manus, or fore foot (left), ... 101

s —Scaphoid.
l —Lunar.
p —Pyramidal.
tm —Trapezium.
tr —Trapezoid.
un —Unciform.
I —First digit, or pollex.
II —Second digit.
III—Third digit.
IV—Fourth digit.
V —Fifth digit.

FIG. 2.—Pes, or hind foot (left), ... 145

a —Astragalus.
c —Calcaneum.
cb —Cuboid.
n —Navicular.
en —Entocuneiform.
I —First digit, or hallux.
II —Second digit.
III—Third digit.
IV—Fourth digit.
V —Fifth digit.

2



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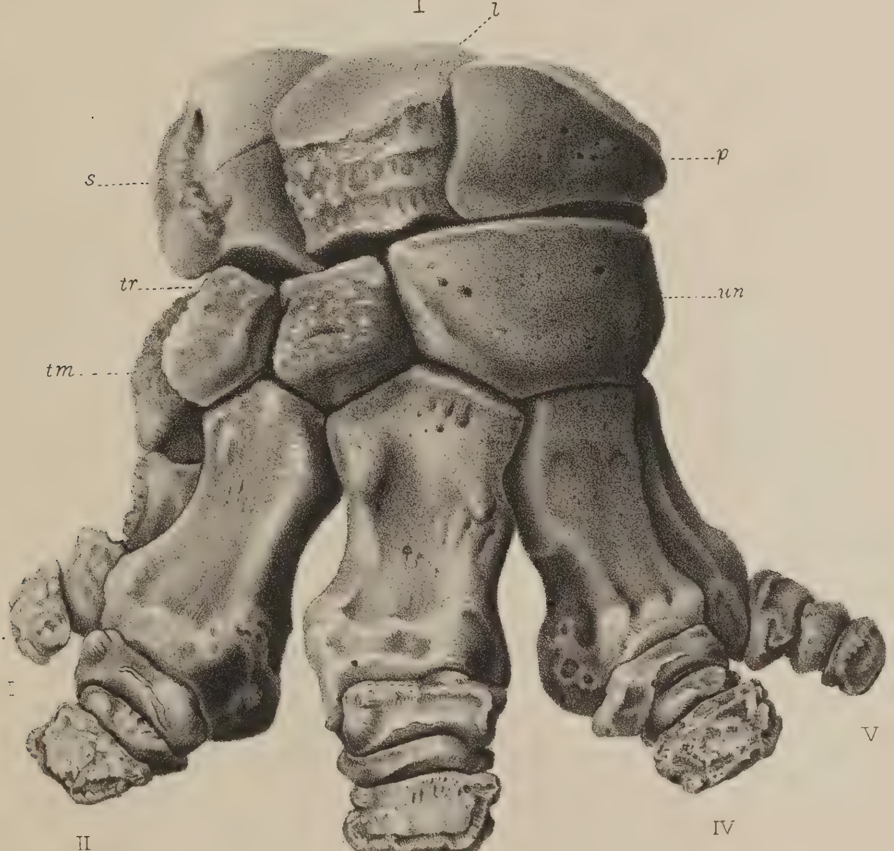


E. Crisand, del.

E. Crisand, lith New Haven

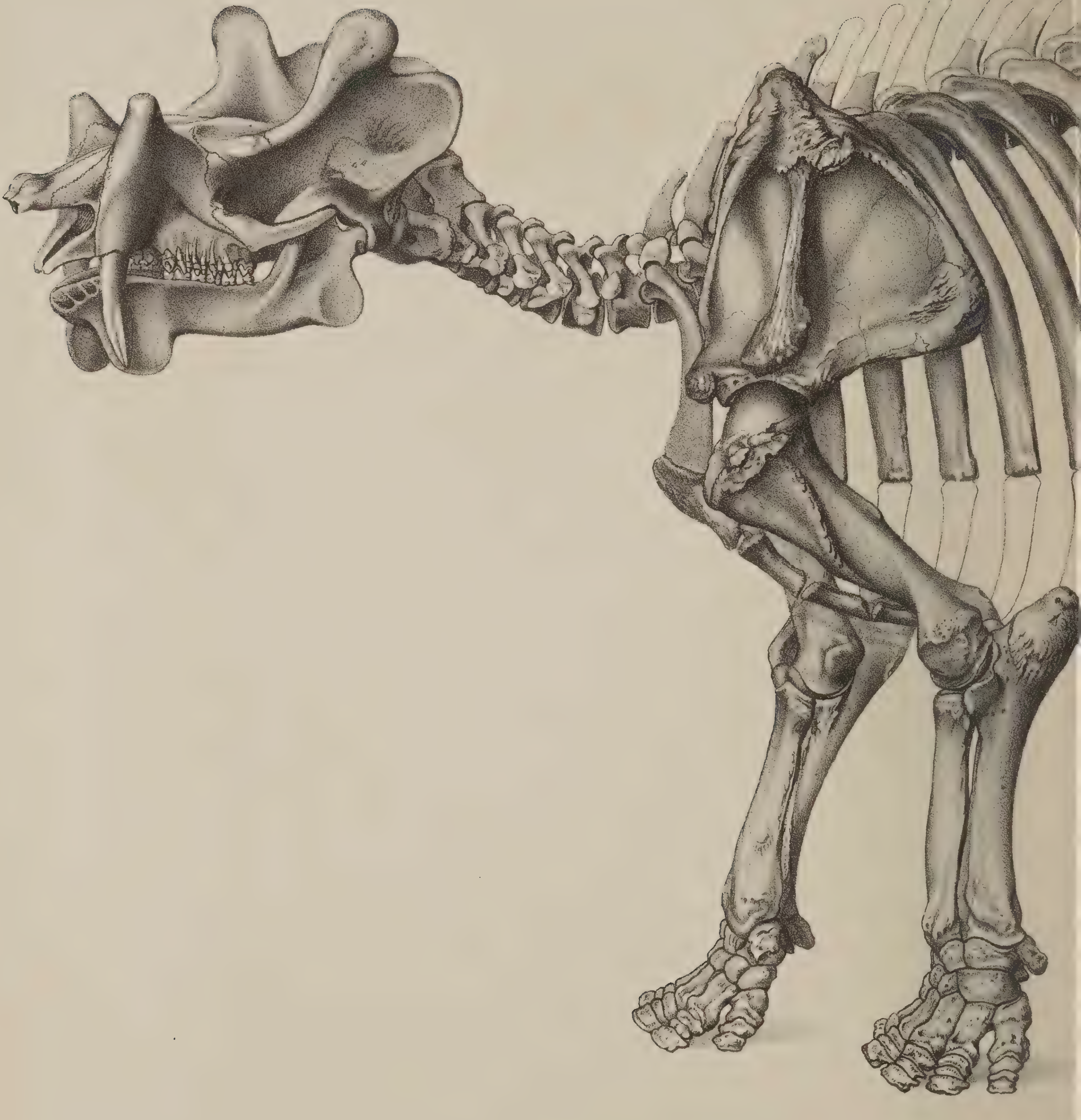
DINOCERAS MIRABILE, Marsh. ½.

PLATE LV.

PLATE LV.

DINOCERATA.

One-eighth Natural Size.



[illegible], del.

DINOCERAS

E. Crisand, lith New Haven

RABILE, Marsh ⅛.

PLATE LVI.

PLATE LVI.

DINOCERATA.

	Page.
Restoration of TINOCERAS INGENS, Marsh.	165

One-sixth Natural Size.